

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXVIII.

FEBRUARY 14, 1908.

No. 4

ANNUAL GENERAL MEETING.

H. F. NEWALL, Esq., M.A., F.R.S., PRESIDENT, in the Chair.

The Report of the Auditors of the Treasurer's accounts for the year 1907 was read, and is given on p. 224.

The Annual Report of the Council was partly read; see pp. 221 to 310.

The Address was delivered by the President, after which the Gold Medal was handed to Sir David Gill, to whom it had been awarded "For his Contributions to the Astronomy of the Southern Hemisphere, and his other Astronomical Work" (see pp. 317 to 330).

Certain alterations to the Bye Laws which had been recommended by the Council, and of which due notice had been given to the Fellows, were put to the Meeting and adopted. [A copy of the Bye Laws as revised is sent to all Fellows of the Society.]

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 331.

The thanks of the Meeting were given to the retiring Members of Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

Henry Hermann Gruning, M.Sc., A.M.Inst.C.E., 3 Blakesley Avenue, Ealing, W.;

Jan Bastiaan Hubrecht, B.A., Ph.D., Christ's College, Cambridge;

Victor A. Lowinger, Trigonometrical Survey Department,
Taiping, Federated Malay States;
Rev. Malcolm Parker Miller McLean, M.A., The Rectory,
West Raynham, Norfolk;
Alfred William Porter, B.Sc., Assistant Professor of Physics,
University College, London, W.C.;
Harold Knox Shaw, B.A., Trinity College, Cambridge; and
Capt. Eldred Weston White, Brockley Villa, Upton Road,
Southville, Bristol,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

John Bullock, M.A., 78 Airedale Avenue, Chiswick, W. (proposed by J. D. McClure);
Arthur Brunel Chatwood, B.Sc., A.M.Inst.C.E., Astronomer to H.H. the Nizam, Hyderabad, Deccan, India (proposed by H. H. Turner);
F. R. Cripps, 22 Hornsey Rise Gardens, N. (proposed by A. C. D. Crommelin);
Henry Zouch Darrah, C.S.I., Indian Civil Service, Junior Carlton Club, Pall Mall, S.W. (proposed by Sir R. S. Ball);
Charles Gaskell Falkner, M.A., Ireton Bank, Rusholme, Manchester (proposed by Sir Andrew Noble);
Henry William Moore, B.A., 64 Curzon Street, Mayfair, W., and New University Club, St. James's Street, S.W. (proposed by J. J. Atkinson); and
Harold Morris-Airey, M.Sc., Lecturer in Physics, Armstrong College, Newcastle-upon-Tyne (proposed by Thomas Thorp).

REPORT OF THE COUNCIL TO THE EIGHTY-EIGHTH ANNUAL
GENERAL MEETING OF THE SOCIETY.

The following table shows the progress and present state of
the Society :—

	Patron	Honorary Members	Fellows		Associates	Total
			Compounders	Annual Subscribers		
1906 December 31	1	3	260	409	48	721
Since elected	...	...	+4	+21	+1	...
Deceased	...	-1	-8	-6	-5	...
Resigned	...	...	...	-3	...	...
Removals	...	...	+3	-3	...	...
Expelled	...	...	...	-1	...	...
1907 December 31	1	2	259	417	44	723

Major Hills' Account as Treasurer of the Royal

RECEIVED.

Balances, 1906 December 31 :—	£	s.	d.	£	s.	d.
At Bankers', as per Pass-book	14	1	0			
In hand of Assistant Secretary on Account of Turnor and Horrox Fund	4	6	0			
In hand of Assistant Secretary on Petty Cash Account	0	17	5			
				19	4	5
Dividends :—						
£1,250 Metropolitan 3-per-cent. Stock ...	35	12	8			
£1,964 12 7 Swansea Corporation 3½-per-cent. Stock	65	6	6			
£3,400 East Indian Railway 3-per-cent. De- benture Stock	96	18	0			
£3,200 London and North-Western Railway 3-per-cent. Debenture Stock	91	4	0			
£4,000 Midland Railway 2½-per-cent. Deben- ture Stock	95	0	0			
£500 Lancashire and Yorkshire Railway 3-per- cent. Consolidated Preference Stock ...	14	5	0			
£1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock	53	0	2			
£1,650 Commercial Gas Co. 3-per-cent. Deben- ture Stock	47	0	6			
				498	6	10
Received on account of Subscriptions :—						
Arrears	129	3	0			
Annual Contributions for 1907	573	6	0			
„ „ in advance	8	8	0			
Admission Fees	52	10	0			
First Contributions	36	15	0			
				800	2	0
Composition Fees... ..				175	7	0
Sales of Publications, &c. :—						
At Williams & Norgate's, 1906	44	18	1			
At Society's Rooms, 1906	108	5	2			
Sales of Photographs, 1907	54	17	0			
				208	0	3
Income Tax refunded by Commissioners of Inland Revenue				26	14	11
				£1,727	15	5

Examined and found correct.

RICHARD INWARDS.
G. J. NEWBEGIN.
A. E. CONRADY.

Astronomical Society, from 1907 January 1 to December 31.

PAID.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
Editing Society's Publications	50	0	0			
Clerk's Salary	75	0	0			
				375	0	0
House Duty	2	12	6			
Fire and Servants' Insurance	9	12	6			
				12	5	0
Printing, &c.:—						
<i>Monthly Notices</i> (Spottiswoode & Co.)	41	12	3			
" (Neill & Co.)	327	14	1			
Appendix to <i>Memoirs</i> (Harrison & Sons)	21	10	0			
List of Fellows (Neill & Co.)	15	16	0			
Miscellaneous (Spottiswoode & Co.)	16	7	6			
Photo-Engraving for <i>Monthly Notices</i> (A. E. Dent & Co.)	13	5	1			
				436	4	11
Turnor and Horrox Fund, purchase of books for						
Library	23	3	6			
Binding books in Library	38	17	4			
				62	0	10
Reproduction of Photographs (Hinton & Co.)				41	16	4
Cataloguing Astronomical Literature for the International Catalogue of Scientific Literature				30	0	0
Expenses of Meetings	20	7	11			
Lantern expenses	6	5	2			
Time Signal: rental of wire	5	0	0			
				31	13	1
Postage and Telegrams	94	2	10			
Carriage of Parcels	3	19	4			
Stationery and Office expenses	8	7	5			
" (Spottiswoode & Co.)	2	0	6			
				108	10	1
Album for Photographs of Associates				2	10	0
House expenses: Allowance and sundry expenses	59	0	9			
Coal and Gas	44	19	7			
Electric Light expenses	19	11	11			
Repairing Council-room Chairs (Shoolbred & Co.)	9	15	0			
Sundry Fittings and Repairs	9	13	4			
Sundries	3	18	1			
				146	18	8
Gold Medals (A. Wyon)				52	12	6
Cheque-book and bankers' charges on cheques				0	10	9
Balances, 1907 December 31:—						
At Bankers', as per Pass-book	386	7	8			
Cheques not credited till 1908	27	2	0			
In hand of Assistant Secretary on account of—						
Turnor & Horrox Fund	6	2	6			
In hand of Assistant Secretary on Petty Cash Account	8	1	1			
				427	13	3
				£1,727	15	5

Report of the Auditors.

We have examined the Treasurer's account of receipts and expenditure for the year 1907, and have found and certified the same to be correct. The cash in hand on December 31, 1907, including the balance at the bankers', etc., amounted to £427, 13s. 3d.

The funded property of the Society is the same as at the end of the previous year, but we are glad to report an improvement in the financial position of the Society, as shown by the balance on December 31, which exceeds that of January 1, 1907, by more than £400.

We have examined the Stock Certificates and the Bank of England verification of the Inscribed Stock standing in the name of the Society.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

(Signed) RICHARD INWARDS.
G. J. NEWBIGIN.
A. E. CONRADY.

Bequests to the General Funds of the Society.

The Carrington Bequest (1876): A sum of £2,000 Consols. Sold in 1899, and stands now in £1,881 14s. London and North-Western Railway 3-per-cent. Debenture Stock.

The McClean Bequest (1905): A sum of £2,000. Invested in Swansea Corporation 3½-per-cent. Stock.

The Farrar Bequest (1906): A sum of £100. Invested in Swansea Corporation 3½-per-cent. Stock.

The cost of reporting Professor Hale's lecture at the special evening meeting on June 26, 1907, was defrayed by Mr. Franklin-Adams.

Trust Funds.

The Turnor Fund: A sum of £464 18s. East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Horrox Memorial Fund: A sum of £103 6s. East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Lee and Janson Fund: A sum of £334 10s. 9d. East Indian Railway 3-per-cent. Debenture Stock; the interest to be given by the Council to the widow or orphan of any deceased Fellow of the Society who may stand in need of it.

The Hannah Jackson (née Gwilt) Fund: A sum of £309 18s. 6d. East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in medals or other awards, in accordance with the terms of the Trust.

Assets and Present Property of the Society, 1908 January 1.

Balances, 1907 December 31 :—

	£	s.	d.	£	s.	d.
At Bankers', as per Pass-book	386	7	8			
Country cheques not credited till 1908 ...	27	2	0			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	6	2	6			
In hand of Assistant Secretary on Petty Cash Account	8	1	1			
				427	13	3

Due on account of Subscriptions :—

4	Contributions of 6 years' standing	...	...	50	8	0
6	"	5	"	...	63	0
9	"	4	"	...	75	12
46	"	2	"	...	193	4
61	"	1	"	...	128	2
Other sums	...	...	...	...	6	6

Less Subscriptions paid in advance	...	...	516 12 0
			8 8 0

508 4 0

Due for Photographs sold	...	...	...	...	...	...	2	0	0
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Due from Williams & Norgate for Publications sold in 1907	...	23	0	9
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£3,400 East Indian Railway 3-per-cent. Debenture Stock, including the Turnor Fund, the Horrox Memorial Fund, the Lee and Janson Fund, and the Hannah Jackson (*née* Gwilt) Fund.

£3,200 London and North-Western Railway 3-per-cent. Debenture Stock (including the Carrington Bequest).

£4,000 Midland Railway 2½-per-cent. Debenture Stock.

£500 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock.

£1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock.

£1,650 Commercial Gas Co. 3-per-cent Debenture Stock.

£1,250 Metropolitan 3-per-cent. Stock.

£1,964 12 7 Swansea Corporation 3½-per-cent. Stock (the McClean and Farrar Bequests).

Astronomical and other Manuscripts, Books, Prints, Photographs, and Instruments.

Furniture, &c.

Stock of Publications of the Society.

Four Gold Medals.

Celestial Photographs.

The following is a list of reproductions of Celestial Photographs published by the Royal Astronomical Society for sale to the Fellows:—

R.A.S. Ref. No.	Subject.	Photographed by
1	Total Solar Eclipse, 1889 January 1	W. H. Pickering
2	Total Solar Eclipse, 1893 April 16	J. M. Schaeberle
3	Total Solar Eclipse, 1886 August 29	A. Schuster
4	Nebulae in the <i>Pleiades</i>	Isaac Roberts
5	Nebula M 74 <i>Piscium</i> (N.G.C. 628)	Isaac Roberts
6	Great Nebula in <i>Orion</i>	Isaac Roberts
7	Milky Way near M 11	E. E. Barnard
8	Milky Way near Cluster in <i>Perseus</i>	E. E. Barnard
9	Comet <i>c</i> 1893 IV. (Brooks), 1893 October 21	E. E. Barnard
10	Comet <i>a</i> 1892 I. (Swift), 1892 April 7	E. E. Barnard
11	Nebula about η <i>Argus</i>	David Gill
12	Portion of Moon (Hyginus-Albategnius)	Loewy and Puiseux
13	Comet <i>c</i> 1893 IV. (Brooks), 1893 October 22	E. E. Barnard
14	Comet <i>c</i> 1893 IV. (Brooks), 1893 October 20	E. E. Barnard
15	Comet <i>c</i> 1893 IV. (Brooks), 1893 November 10	E. E. Barnard
16	Comet <i>a</i> 1892 I. (Swift), 1892 April 26	E. E. Barnard
17	Comet <i>f</i> 1892 III. (Holmes), 1892 November 10	E. E. Barnard
18	Comet <i>a</i> 1892 I. (Swift), 1892 April 18	E. E. Barnard
19	Portion of Moon (Alps, Apennines, &c.)	Loewy and Puiseux
20	Nebula in <i>Andromeda</i>	Isaac Roberts
21	<i>Jupiter</i> , 1892 September 26	Lick Observatory
22	Cluster M 13 <i>Herculis</i> (N.G.C. 6205)	W. E. Wilson
23	Total Solar Eclipse, 1893 April 16 (5 sec.)	J. Kearney
24	Total Solar Eclipse, 1893 April 16 (20 sec.)	J. Kearney
25	The Moon (Age 7 ^d 3 ^h)	Lick Observatory
26	The Moon (Age 12 ^d 6 ^h 1 ^h)	Lick Observatory
27	The Moon (Age 16 ^d 18 ^h)	Lick Observatory
28	The Moon (Age 23 ^d 8 ^h)	Lick Observatory
29	The Sun, 1892 February 13	Roy. Obs., Greenwich
30	The Sun, 1892 July 8	Roy. Obs., Greenwich
31	Portion of Moon (Region of Maginus)	Loewy and Puiseux
32	The Moon (Age 14 ^d 1 ^h)	Lick Observatory
33	Portion of Moon (Ptolemæus, &c.)	Lick Observatory
34	Portion of Moon (Mare Serenitatis)	Lick Observatory
35	Portion of Moon (Clavius, Licetus, &c.)	Lick Observatory

R.A.S. Ref. No.	Subject.	Photographed by
36	Portion of Moon (Regiomontanus, &c.)	Lick Observatory
37	Portion of Moon (Tycho, Thebit, &c.)	Lick Observatory
38	Portion of Moon (Theophilus, &c.)	Lick Observatory
39	Total Solar Eclipse, 1896 August 9 (3 sec.)	S. Kostinsky
40	Total Solar Eclipse, 1896 August 9 (26 sec.)	A. Hansky
41	Cluster M 56 <i>Lyræ</i> (N.G.C. 6779)	
42	Nebulæ M 81, 82 <i>Ursæ Majoris</i> (N.G.C. 3031, 3034)	
43	Cluster M 56 <i>Lyræ</i> (N.G.C. 6779) (enlarged)	
44	Solar Corona, 1871 December 12, Baikul	H. Davis
45	Solar Corona, 1875 April 6, Siam	Lockyer and Schuster
46	Solar Corona, 1878 July 29, Wyoming	W. Harkness
47	Solar Corona, 1882 May 17, Egypt	Abney and Schuster
48	Solar Corona, 1883 May 6, Caroline Island	Lawrance and Woods
49	Solar Corona, 1885 Sept. 9, Wellington, N.Z.	Radford
50	Solar Corona, 1886 August 29, Grenada, W.I.	A. Schuster
51	Solar Corona, 1887 August 19, Japan	M. Sugiyama
52	Solar Corona, 1889 January 1, California	W. H. Pickering
53	Solar Corona, 1889 December 22, Cayenne	J. M. Schaeberle
54	Solar Corona, 1893 April 16, Fundium	J. Kearney
55	Solar Corona, 1893 April 16, Brazil	A. Taylor
56	Great Nebula in <i>Orion</i>	W. E. Wilson
57	Dumb-bell Nebula, <i>Vulpecula</i> (N.G.C. 6853)	W. E. Wilson
58	Spiral Nebula, <i>Canes Venatici</i> (N.G.C. 5194-5)	W. E. Wilson
59	Ditto (enlarged) (N.G.C. 5194)	W. E. Wilson
60	Annular Nebula, <i>Lyra</i> (N.G.C. 6720)	W. E. Wilson
61	Meteor Trail and Comet Brooks, 1893 Nov. 13	E. E. Barnard
62	Total Solar Eclipse, 1898 January 22 (5 sec.)	W. H. M. Christie
63	Total Solar Eclipse, 1898 January 22 (20 sec.)	W. H. M. Christie
64	Solar Corona, 1896 August 9, Novaya Zemlya	G. Baden-Powell
65	Solar Corona, 1898 January 22, Pulgaon, India	E. H. Hills
66	Nebula in <i>Andromeda</i>	Roy. Obs., Greenwich
67	Spectrum of Sun's Limb, 1898 January 22	E. H. Hills
68	Annual Nebula, <i>Lyra</i> (N.G.C. 6720)	Lick Observatory
69	Dumb-bell Nebula, <i>Vulpecula</i> (N.G.C. 6853)	Lick Observatory
70	Spiral Nebula, <i>Canes Venatici</i> (N.G.C. 5194-5)	Lick Observatory
71	Spiral Nebula, <i>Ursa Major</i> (N.G.C. 5457)	Lick Observatory
72	Trifid Nebula, <i>Sagittarius</i> (N.G.C. 6514)	Lick Observatory
73	Great Nebula in <i>Orion</i>	Lick Observatory
74	Cluster M 13 <i>Herculis</i> (N.G.C. 6205)	Lick Observatory
75	Solar Surface with Faculæ, 1893 August 7	G. E. Hale

R.A.S. Ref. No.	Subject.	Photographed by
76	Faculae and Prominences, 1892 June 25	G. E. Hale
77	Total Solar Eclipse, 1898 Jan. 22 ($\frac{2}{3}$ sec.)	W. H. M. Christie
78	Nebula H V, 14 <i>Cygni</i> (N.G.C. 6992)	W. E. Wilson
79	Portion of Moon (Theophilus, &c.)	Yerkes Observatory
80	Total Solar Eclipse, 1900 May 28 (30 sec.)	E. E. Barnard
81	Comet 1901 I., 1901 May 4	Roy. Obs., Cape of G. H.
82	Comet 1901 I., 1901 May 6	Roy. Obs., Cape of G. H.
83	Comet 1901 I., 1901 May 9	Perth Obs., W. Australia
84	Solar Surface with Faculae, 1895 August 18	H. Deslandres
85	Solar Prominences, 1894 April 11	H. Deslandres
86	Nebula about Nova <i>Persei</i> , 1901 Sept. 20	G. W. Ritchey
87	Nebula about Nova <i>Persei</i> , 1901 Nov. 13	G. W. Ritchey
88	Total Solar Eclipse, 1901 May 18 (10 sec.)	F. W. Dyson
89	Total Solar Eclipse, 1901 May 18 (40 sec.)	F. W. Dyson
90	Comet <i>b</i> 1902 III. (Perrine), 1902 Sept. 29	Roy. Obs., Greenwich
91	Portion of Moon (Mare Serenitatis, &c.)	Yerkes Observatory
92	Portion of Moon (Rough Crater Region, Mare Nubium)	Yerkes Observatory
93	Portion of Moon (Tycho, Theophilus, &c.)	Yerkes Observatory
94	Portion of Moon (Bullialdus to Copernicus)	Yerkes Observatory
95	Portion of Moon (Copernicus, enlarged)	Yerkes Observatory
96	Great Nebula in <i>Orion</i>	Yerkes Observatory
97	Great Nebula in <i>Orion</i> (Central portion)	Yerkes Observatory
98	Nebula in <i>Andromeda</i>	Yerkes Observatory
99	Nebula in <i>Cygnus</i> (N.G.C. 6960)	Yerkes Observatory
100	Nebula in <i>Cygnus</i> (N.G.C. 6992)	Yerkes Observatory
101	Cluster M 13 <i>Herculis</i> (N.G.C. 6205) *	Yerkes Observatory
102	Cluster M 15 <i>Pegasi</i> (N.G.C. 7078)	Yerkes Observatory
103	Solar Surface with Faculae, 1903 April 27	Yerkes Observatory
104	The Moon, 1900 April 5	P. Puiseux
105	The Moon, 1902 November 13	P. Puiseux
106	The Moon, 1903 February 6	P. Puiseux
107	The Moon, 1903 September 12	P. Puiseux
108	Nebulosity about 15 <i>Monocerotis</i>	E. E. Barnard
109	Milky Way about β <i>Cygni</i>	E. E. Barnard
110	Nebulosity near α <i>Cygni</i>	E. E. Barnard
111	Milky Way near χ <i>Cygni</i>	E. E. Barnard
112	Star Cloud in <i>Sagittarius</i>	E. E. Barnard
113	Wilky Way in <i>Cepheus</i>	E. E. Barnard
114	Milky Way about M 8	E. E. Barnard

R.A.S. Ref. No.	Subject.	Photographed by
115	Milky Way about θ <i>Ophiuchi</i>	E. E. Barnard
116	Milky Way near N.G.C. 6475	E. E. Barnard
117	Great Nebula near ρ <i>Ophiuchi</i>	E. E. Barnard
118	Milky Way about 58 <i>Ophiuchi</i>	E. E. Barnard
119	Milky Way near <i>Omega</i> nebula	E. E. Barnard
120	Star Cloud in <i>Sagittarius</i>	E. E. Barnard
121	Nebula about ν <i>Scorpii</i>	E. E. Barnard
122	Sun, 1905 January 30	Roy. Obs., Greenwich
123	Sun-spot, 1905 January 30	Roy. Obs., Greenwich
124	Sun, 1905 January 31	Roy. Obs., Greenwich
125	Sun-spot, 1905 January 31	Roy. Obs., Greenwich
126	Sun, 1905 February 2	Roy. Obs., Greenwich
127	Sun-spot, 1905 February 2	Roy. Obs., Greenwich
128	Sun, 1905 February 3	Roy. Obs., Greenwich
129	Sun-spot, 1905 February 3	Roy. Obs., Greenwich
130	Sun, 1905 February 5	Roy. Obs., Greenwich
131	Sun-spot, 1905 February 5	Roy. Obs., Greenwich
132	Sun, 1905 February 8	Roy. Obs., Greenwich
133	Sun-spot, 1905 February 8	Roy. Obs., Greenwich
134	Nebula near ψ <i>Eridani</i> , 1905 January 8	Max Wolf
135	Nebula M 33 <i>Trianguli</i> (N.G.C. 598)	Isaac Roberts
136	Nebula in <i>Perseus</i> (N.G.C. 1499)	Isaac Roberts
137	Nebula in <i>Monoceros</i> (N.G.C. 2237-9)	Isaac Roberts
138	Nebula $\mathfrak{H}$ V. 24 <i>Comæ</i> (N.G.C. 4565)	Isaac Roberts
139	Nebulae $\mathfrak{H}$ V. 42, &c., <i>Comæ</i> (N.G.C. 4631)	Isaac Roberts
140	Nebulae $\mathfrak{H}$ V. 37 <i>Cygni</i> (N.G.C. 7000?)	Isaac Roberts
141	Nebula Index Cat. 405 <i>Persei</i>	Isaac Roberts
142	Clusters in <i>Perseus</i> (N.G.C. 869, 884)	Isaac Roberts
143	Cluster $\mathfrak{H}$ VI. 30 <i>Cassiopeiæ</i> (N.G.C. 7789)	Isaac Roberts
144	Eclipse, 1905 August 30 (5 sec.)	W. H. M. Christie
145	Eclipse, 1905 August 30 (20 sec.)	W. H. M. Christie
146	Eclipse, 1905 August 30 (7 sec.)	W. H. M. Christie
147	Eclipse, 1905 August 30 (20 sec.)	W. H. M. Christie
148	Eclipse, 1905 August 30 (Portion)	W. H. M. Christie
149	Region of Nebula ρ <i>Ophiuchi</i>	E. E. Barnard
150	Nebula ρ <i>Ophiuchi</i> (enlarged)	E. E. Barnard
151	Region of θ <i>Ophiuchi</i>	E. E. Barnard
152	Great Rift near θ <i>Ophiuchi</i>	E. E. Barnard
153	Great Star Cloud in <i>Sagittarius</i>	E. E. Barnard
154	Small Star Cloud in <i>Sagittarius</i>	E. E. Barnard

R.A.S. Ref. No.	Subject.	Photographed by
155	Region of Cluster M 11	E. E. Barnard
156	Sun-spots, 1906 July 6	Roy. Obs., Greenwich
157	Sun-spot, 1906 July 31	Roy. Obs., Greenwich
158	Sun-spot, 1906 August 30	Roy. Obs., Greenwich
159	Eclipse, 1905 August 3 (large prominence)	De la Baume Pluvinel

Nos. 44-55, Nos. 64, 65, and No. 147 form a series of corona photographs, oriented and reduced to the same scale.

The above photographs are now on sale to Fellows as prints, either platinotype or aristotype, mounted on sunk cut-out mounts, measuring 12 inches by 10 inches; also unmounted, and as lantern slides. Nos. 44-55 and Nos. 64 and 65 are also supplied as transparencies, $6\frac{1}{4}$ inches square.

Price of prints, mounted 1s. 6d. each, unmounted 1s. each; lantern slides, 1s. each; packing and postage extra.

Transparencies, $6\frac{1}{4}$ inches square (Nos. 44-55 and Nos. 64 and 65), 3s. 6d. each.

Orders to be addressed to W. H. Wesley, Burlington House, London, W. In ordering prints or slides the R.A.S. Reference No. only need be quoted, but in the case of prints it should be stated whether platinotypes or aristotypes are required, and whether mounted or unmounted.

The Gold Medal.

The Council have awarded the Gold Medal of the Society to Sir David Gill, K.C.B., for his Contributions to the Astronomy of the Southern Hemisphere and his other Astronomical Work. The President, in his Address to the Society, gives the grounds upon which the award has been founded.

Publications of the Society.

During the past year vol. lxvii. of the *Monthly Notices* has been issued.

The following paper, reprinted from the *Philosophical Transactions* of the Royal Society, has been issued as an appendix to the *Memoirs*:—

F. W. Dyson, Determination of Wave-length from Spectra obtained at the total solar eclipses of 1900, 1901, 1905.

OBITUARY.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year :—

Honorary Member :—Agnes Mary Clerke.*

Fellows :—Alexander Stewart Herschel.

William Johnston.*

Zufur Jung.

Lord Kelvin.

David Joseph Kennelly.

Peter Matthews.

Thomas Perkins.

James George Petrie.

Edward Power.

George William Read.

Thomas Robson.

Edward John Routh.

Henry Chamberlain Russell.

William Simms.*

Associates :—Asaph Hall.

Jules Janssen.

Maurice Loewy.

Charles Trépied.

Hermann Carl Vogel.

An obituary notice is also given of James Kennedy Esdaile, who died in January 1908.

JAMES KENNEDY ESDAILE, the eldest son of the late Edward Esdaile, of Ockly, Surrey, was born in 1840. He was educated at Charterhouse, and afterwards at Peterhouse, Cambridge, taking his M.A. degree in 1871. In 1876 he married Florence, only daughter of the late George Crawshay, of Houghton Castle, Tyneside, Northumberland. Until 1889 he lived at Saint Hill, near East Grinstead, where he had a small private observatory and occupied himself in observation of sun-spots. More recently he lived at Horsted Keynes, where he died, 1908 January 6. He was a Magistrate and Deputy-Lieutenant for Sussex, and in 1881 was High Sheriff for the county.

He was elected a Fellow of the Society 1872 February 9.

ALEXANDER STEWART HERSCHEL was the second son of Sir John Herschel, and the fifth of twelve children. He was born at the Cape of Good Hope in 1836, during the historic astronomical

* Obituary in Annual Report for 1906.

expedition of his father. He went (1851-55) to the famous Clapham Grammar School, where the Rev. C. Pritchard was doing pioneer work in the way of a scientific education for boys; and thence to Trinity College, Cambridge (1855-59), and to the Royal School of Mines (1861-5). He was then (1866) appointed Professor of Mechanical and Experimental Physics in the University of Glasgow, a position which he resigned in 1871 in favour of a corresponding Professorship at Durham; and from this he retired in 1886. From 1888 till his death in 1907 he lived with brother and sisters at Observatory House, Slough, the former residence of his grandfather.

Alexander Herschel was best known for his work on luminous meteors. He was himself a diligent observer, spending long hours in the open in the watch for meteors. His post of astronomical observation at Slough was necessarily different from that of his grandfather, for during the half-century following the death of Sir William trees had grown up in the garden where his great telescope used to stand; and when four of his grandchildren returned to Observatory House in 1888 (after half a century of occupation by strangers) they found a pleasantly shaded garden, but no horizon visible. Over the wall, however, in the kitchen-garden, where Sir William's forges and optical works used to be, there were no trees; and there Alexander Herschel would lie on his back and watch the broad sky for meteors. His observations are contained in a long series of small note-books, and every observation is numbered, starting each new year with unity again. The last observation is dated 1907 February 13. A hasty glance at these books with unskilled eyes suggests that probably there is a great deal of valuable material of which no use has yet been made. But a proper estimate of the value of his work in this field can only be given by a meteor observer, and Mr. W. F. Denning has very kindly written the following notes:—

“Professor Herschel's meteoric work was characterised by its remarkable accuracy, its comprehensive detail and large amount, extending over something like half a century. It not only embraced his personal observations, but comprised the comparison and reduction of a great number of materials sent in to him by various other observers in England and abroad. During a long series of years he collected as many descriptions as possible of the fire-balls which appeared from time to time, and calculated their real paths in the atmosphere.

“As a result of long practice, he acquired great precision in noting the flights of individual meteors amongst the stars, and could reproduce them on his charts with unusual fidelity. He observed the great meteoric showers of 1866, 1872, and 1885, and collected together the different values for the positions of radiation, and obtained their mean places. It was from his averaged radiant for the November Leonids of 1866 that Professor Schiaparelli was successfully enabled to deduce his conclusions on the virtual identity of the orbits of this meteoric stream and Tempel's comet of 1866.

"An important paper by Professor Herschel appeared in the *Monthly Notices* for 1872, in which he called attention to certain showers presumably connected with Biela's periodical comet, and he pointed out the probability of a recurrence of the shower at the end of November 1872, advising observers to maintain a watch of the sky at this particular period. His anticipations were realised in a very notable manner by the occurrence, on November 27, of one of the grandest meteoric exhibitions of modern times, which fully substantiated the theory of close association existing between comets and meteors, and certainly demonstrated that the slow meteors returning at intervals at the end of November really represented the *débris* of the lost comet of Biela.

"Valuable work was accomplished by Professor Herschel in the calculation of the radiant points of comets. A complete list of his results, forming a valuable summary for reference and comparison, was published in the British Association Report, 1875, and in the same volume and also in *Monthly Notices*, vol. xxxviii. p. 369, he gave lists of known accordances between cometary and observed meteor showers. In collaboration with Mr. R. P. Greg, he formed several catalogues of the radiant points of meteors observed by the British Association members, including one giving 88 positions in 1868, and another of 63 positions in 1875 (British Association Reports, 1868, 1872, 1875)."

But though the work on meteors engrossed the greater part of his scientific activity, Alexander Herschel had many other interests. One of the chief of these was photography. His father was a keen and original photographer—the first man, it will be remembered, to use glass as a support for a photographic film (and the first picture he took in this way was of *his* father's great telescope). Alexander's devotion to photography was thus hereditary; and here, again, he not only worked assiduously himself, but stimulated activity in others. In 1893 his portrait was presented to the South Kensington Museum by the Amateur Photographic Association, and among his treasured possessions was a beautiful album of photographs presented to him by the Newcastle-on-Tyne and Northern Counties Photographic Association (of which he was President, 1885–7) as a "slight acknowledgment of services rendered."

His brother, Colonel J. Herschel, has remarked on his extraordinary vitality; he nearly always *ran*, rather than walked, to his miscellaneous occupations, and his mental activities had two unfortunate results: he shunned the interruptions of society so far as to become practically a recluse, taking all his meals alone, and he became impatient of his bodily needs until the neglect of them shattered his health. He died on June 18, 1907, at the age of seventy-one, and on June 22 was buried in the grave at St. Laurence's Church at Upton, where his famous grandfather had been laid eighty-five years before.

He was elected a Fellow of the Society 1867 March 8.

H. H. T.

WILLIAM THOMSON, BARON KELVIN of Largs, was born at Belfast, June 24, 1824. He was the second son of James Thomson, who, descended from a small farmer in the north of Ireland, in 1832 became Professor of Mathematics in the University of Glasgow. The James Thomson who in 1872 succeeded Rankine as Professor of Engineering at Glasgow was Lord Kelvin's elder brother. In 1834 he became a matriculated member of the University, and at the age of 15, during a fortnight's visit to Germany, he read Fourier's treatise to such purpose that soon after his return he wrote a series of papers in which he successfully defended Fourier from a charge of unsoundness brought against him, through some misconception, by a very competent mathematician. In 1841 he proceeded to Peterhouse, Cambridge; he was very youthful-looking and was known as "the pretty boy," but, despite his youth, he won the Colquhoun Sculls in 1843, which, it is interesting to note, had been won the previous year by the Hon. G. (afterwards Mr. Justice) Denman. He was also one of five Peterhouse men who founded the University Musical Society, the only survivor being Bishop Cridge of Victoria, B.C., who is now 86. While still an undergraduate he published papers in the *Cambridge Mathematical Journal* on the Motion of Heat, and the Mathematical Theories of Electricity and Attractions. In 1845 he graduated as Second Wrangler and first Smith's prizeman; he was almost immediately elected a Fellow of his College, and then he spent a short time in Regnault's laboratory in Paris. The next year he was appointed to the Chair of Natural Philosophy at Glasgow, which he continued to hold for fifty-three years: on resigning the Professorship he applied to be appointed as a research student; and in 1904 he was installed as Chancellor of the University.

To give even the titles of the papers he published on various branches of mathematics and physics, and the names of the instruments he invented, would require more space than could be allotted to this notice. His great strength lay in the wonderful faculty he possessed for directly applying the results of the most abstruse mathematical investigations to the solution of practical problems, and in the mechanical ingenuity which enabled him to invent instrument after instrument which satisfied, almost to perfection, the requirements indicated by the most refined analysis. It was Professor Newcomb who said, on the occasion of Lord Kelvin's jubilee in 1896: "It has been the general—I do not know but that it has been the almost universal—rule that the men who have by their studies and thought promoted our knowledge of nature, have not been those who have applied that knowledge to the direct benefit of mankind. I am not sure but that Lord Kelvin is the single, solitary exception to this rule."

His direct contributions to Astronomy were not numerous compared with the rest of his work, but he has told us that he learnt from Stokes before the end of 1851 that the existence of the D line in the solar spectrum proved the presence of sodium in the Sun, and from that date he regularly taught this fact in his

lectures; Kirchoff's work was not published until 1859. In 1862 he presented a paper to the Royal Society of Edinburgh in which he showed from the equations representing the conduction of heat in a solid that the present distribution of underground temperature necessarily implied a finite limit to the age of the Earth, and he fixed the date of its consolidation at between twenty and four hundred millions of years ago. An address on Geological Time, given to the Geological Society of Glasgow in 1868, led to a lively controversy with Huxley, in which he maintained that the fact that the oblateness of the Earth corresponds with the present length of the day shows that the Earth could not have been rotating with much greater velocity when it solidified, and that the retardation due to tidal friction therefore enables us to assign a limit to the time within which this must have happened. He also endeavoured, by means of the conservation of energy, to fix a limit to the time during which the Sun could, by its radiation, have kept the Earth at a temperature at which organic life is possible. It should, however, be mentioned, with regard to the argument from the figure of the Earth, that Sir George Darwin believes the Earth to have a greater power of adjusting its figure to its rate of rotation than Lord Kelvin thought possible. It was just after the conclusion of this controversy that Huxley introduced Sir William Thomson (as he then was) as his successor in the Presidency of the British Association with the words, "gentler knight never broke lance." Returning to the same subject thirty years later, with a more complete knowledge of underground temperature, Lord Kelvin placed the date of solidification at "more than twenty and less than forty millions of years ago, and probably much nearer twenty than forty." The discovery of the properties of radium has, however, diminished the force of these arguments, whether derived from the conduction of heat in the interior of the Earth, or from the age of the Sun's heat.

These investigations, as well as the principle of the dissipation of energy, which was stated in a paper presented to the Royal Society of Edinburgh in 1852, and in the *Philosophical Magazine* for the same year, have a direct bearing on cosmical physics and on the evolution of stellar systems.

Lord Kelvin also gave much attention to the rigidity of the Earth, as evidenced by the phenomena of precession and the tides. He took up the former problem where it was left by Hopkins, and, by amending his argument, he showed that it led to the conclusion that either the globe is solid throughout, or else the crust yields with nearly the same freedom to external forces as if it were liquid. He then compared the heights of oceanic tides on a perfectly rigid globe with those on globes possessing the rigidities of glass and steel respectively, and, from the best data available, concluded that the average stiffness of the Earth is greater than that of glass, but perhaps not greater than that of steel. His work on the Tides in general and the construction of his "Tide Predictor" afford a very good illustration of his

power of first dealing with theory and then translating it into practice.

He effected many improvements in navigation. He published a set of tables for facilitating the use of Sumner's method for determining the position of a ship. In 1876 he patented a compass in which the single, large, strongly magnetised needle formerly used is replaced by eight small parallel magnets of comparatively feeble intensity; he was thus able to secure lightness and long vibrational period, giving greater steadiness to the compass; the short needles allowed the correction to be accurate on all courses of the ship, for the place where the adjustment was made, and the small magnetic moment allowed the correction of the quadrantal error to remain accurate for all parts of the world. As an illustration of his attention to minute details, it may be noted that 32 radial slits were given to the card to prevent warping. This compass is now in almost universal use, as is also the deep-sea sounding apparatus, which is frequently the only means by which a sailor can determine his position when neither land nor sky is visible.

One of the greatest of the indirect benefits which Lord Kelvin conferred upon Astronomy was through ocean telegraphy, which has rendered possible the accurate determination of longitudes. To this achievement he contributed more than any other person, whether by demonstrating its theoretical possibility in opposition to Sir George Airy, by showing that the shortness of the life of the first Atlantic cable of 1858 was due to the intensity of the currents used in signalling, or by his invention of the mirror galvanometer and siphon recorder, which rendered possible the use of comparatively feeble currents.

He was knighted in 1866 as a recognition of his services in connection with the first Atlantic cables of 1858, 1865, and 1866. He had been elected a Fellow of the Royal Society in 1851; he subsequently received a Royal and a Copley medal, and was elected President in 1890. He was President of the Royal Society of Edinburgh 1887-90, and again from 1895 to the time of his death, and President of the British Association at the Edinburgh meeting in 1871. In 1892 he was created a Peer, taking his title from the small stream at the foot of the hill on which the University of Glasgow stands. He was one of the first recipients of the Order of Merit at its creation in 1902, and he became a Privy Councillor in the same year.

Nothing could show more clearly the estimation in which Lord Kelvin was held, both at home and abroad, than the celebration of the jubilee of his professoriate at Glasgow in 1896. Delegates from all parts of the world presented addresses; those from the Institute of France brought the Arago medal, which had been bestowed upon only three previous recipients. Congratulations were received from the Queen and the Prince of Wales, and telegrams from Europe, Asia, Africa, America, and Australasia.

Lord Kelvin was twice married: first to Margaret, daughter of Mr. Walter Crum, of Thornliebank; and secondly, to Frances Anna,

daughter of Mr. Charles R. Blandy, of Madeira. There was no issue of either marriage. He died at Netherhall, Largs, on December 17, and was laid to rest in Westminster Abbey on December 23; his grave is by the side of that of Sir Isaac Newton.

He was elected a Fellow of the Society 1868 November 13.

S. A. S.

DAVID JOSEPH KENNELLY was born at Cork, Ireland, on October 1, 1831, and was the son of David Nugent Mountjoy Kennelly and Zaida Teresa de la Romana Kennelly, *née* Marquesa de la Romana, of Las Palmas, Minorca. He went to sea as midshipman in 1846, and was rapidly promoted in the service of the Royal East India Company's Navy. He was made second sailing-master of H.M.S. *Meteor* in 1849, and, as master of the frigate *Ferooz*, in 1853 conveyed the 10th Lancers from Cananore to Suez, on their way to the Crimea. In the same year he served on board the frigate *Akbar* on an expedition to the Persian Gulf and the Euphrates, bringing to Bombay Layard's Nineveh slabs now in the British Museum. He was accustomed to compute the daily longitudes as well as latitudes mentally, with the aid of the regular tables, but without pencil or paper. The science of astronomy especially interested him in relation to navigation.

At the outbreak of the Indian Mutiny in 1857 Captain Kennelly was Naval A.D.C. to the Governor of Bombay. He was immediately sent, as master of a frigate, with despatches to the General commanding at the Cape of Good Hope, calling for such troops as South Africa could spare. He brought back to India H.M. 89th regiment of infantry, and landed them into action at the Gulf of Cambay. Returning to Bombay, he assisted in the disarmament of three mutinous sepoy regiments. He was twice mentioned in despatches in recognition of services.

After the Indian Mutiny, Captain Kennelly was appointed a Joint Commissioner of Bombay, and master-attendant in charge of H.M. dockyard at that port. He held this appointment until he retired from Indian service in 1868 and returned to Great Britain. He studied law in London from 1872 to 1876, and was admitted to the bar at the Inner Temple, pleading for some years in the Admiralty Court at Westminster. Later he became a barrister of the Supreme Court of Nova Scotia, and was appointed a K.C. of the province of Cape Breton. He made his home in Louisburg, Cape Breton, and was for many years connected with the coal-mining industries of that province.

Captain Kennelly received a diploma from the University of Bombay, and was at the time of his death the senior honorary corresponding member of the Royal Geographical Society, whose diploma he received for Oriental geographical research. He died at Sydney, Cape Breton, on August 27, 1907, bequeathing a fund for the maintenance and preservation of a portion of the old French citadel at Louisburg, Cape Breton, and for the protection of its historical relics. He had already presented the land for this pur-

pose to the town of Louisburg. He is survived by ten children. He was elected a Fellow of the Society 1864 January 8.

The Rev. THOMAS PERKINS was educated at Blundell's School, Tiverton, and at Christ's College, Cambridge. He took his degree in 1865, when he was bracketed 20th wrangler, Lord Rayleigh being the senior wrangler that year. He was ordained Deacon in 1868 and Priest in the following year by the Bishop of Durham, and after holding mathematical masterships at Durham and Reading Schools he was in 1878 appointed Headmaster of the Shaftesbury Grammar School. In 1893 he was presented by the Bishop of Salisbury to the living of Turnworth, Dorsetshire, which he held until his death on March 21, in the 65th year of his age. He took great interest in architecture, and was the author of *A Handbook to Gothic Architecture* and of several volumes in "Bell's Cathedral Series." At the time of his death he had just completed a book on Romsey Abbey Church, and was engaged in editing, and partly writing, a book to be entitled *Memoirs of Old Dorset*. He was an enthusiastic photographer, and enjoyed a well-earned reputation for the artistic merit of his work.

Mr. Perkins was elected a Fellow of the Society 1885 June 12.

JAMES GEORGE PETRIE was a native of Kirkcaldy, Fifeshire. He came to London at an early age and engaged in financial journalism. He soon made himself highly respected in the City, and for the last sixteen years had been chief of the reporting staff of the *Financial Times*. He was for a time President of the Shorthand Society in London. He was an ardent volunteer, and on coming to London joined the London Scottish; he left that regiment as a non-commissioned officer to take a commission as second lieutenant in the 21st Middlesex, from which he retired quite recently as a major. He received the V.D. for long service, and was one of the most popular officers in the battalion. He was an original member of the British Astronomical Association, served on the Council 1892-1894, and was Secretary from 1894 until his death, which occurred on September 22, after a long illness. He was in his 60th year. He was twice married, and leaves a widow with four children.

Mr. Petrie was elected a Fellow of the Society 1889 May 10.

THOMAS ROBSON was born at Lisburn, Co. Antrim, on 19th June 1868. He served as a pupil teacher at the Spring Grove Board School, Huddersfield, from 1883 to 1887, as assistant master at Rastrick Grammar School from 1887 to 1889, and at the Ulster Provincial School, Lisburn, from 1890 to 1892. In 1893 he took his B.A. degree at London University, and the next year he returned to his previous post at the Ulster Provincial School. Here he remained until 1897, when he again came to London as a student at the Royal College of Science. He passed the intermediate examination for the B.Sc. in 1899, and the next year he was appointed Science

Master at Doncaster Grammar School, a post he held until his death, which occurred on April 5.

He married Eliza Williams, of Randall's Mills, Co. Wexford, in August 1904, but leaves no family.

He was elected a Fellow of the Society 1903 November 13.

EDWARD JOHN ROUTH was born at Quebec in 1831, and was the son of Sir Randolph Isham Routh, K.C.B., Commissary-General to the British Forces from 1826 to his death in 1858, by his second wife Marie Louise, sister of Cardinal Taschereau, Archbishop of Quebec. The boy came to London at the age of 11, and was educated, first at University College School, and later at the College itself, under De Morgan. He matriculated at London University in 1847, and won two scholarships and a gold medal. He went up to Peterhouse, Cambridge, in 1850; was Senior Wrangler in 1854 (Clerk Maxwell being second, and the two being bracketted for the Smith's Prizes); was elected a Fellow of Peterhouse, appointed Lecturer, and ultimately became a most successful private tutor. In 1864 he married Hilda, eldest daughter of Mr. (afterwards Sir) G. B. Airy, Astronomer Royal, and by the statutes of the time he thus vacated his fellowship, but in 1883 he was elected to the first honorary fellowship at Peterhouse. He gave up private tuition in 1888, though he continued to lecture. His health broke down about the beginning of 1907, and on Friday, June 7, he passed peacefully away.

It may not be easy for future generations to understand the position Routh occupied in Cambridge life, or the debt Cambridge owes to him.

There are, roughly speaking, two ways of giving instruction, one by lectures to large audiences, the other by personal interviews with small groups or individuals. The private tutor was called into existence in Cambridge by the failure of the Colleges and of the University to give any teaching beyond lectures, and sometimes very inadequate lectures. The importance of such "coaching" had been rendered manifest by the success of those who were able to pay for it, and it was easy to recognise that some coaches were better than others by comparing the achievements of their pupils. Routh was practically the successor of a great coach, William Hopkins, with whom he had himself read, and who was able in 1849 to say that in twenty-one years he had had among his pupils nearly 200 wranglers, 17 of them senior wranglers. Routh's own success was even greater, for between 1858 and 1888 he had between 600 and 650 pupils, including 27 senior wranglers. In fact, in the twenty-five years 1861-85 he claimed the senior wrangler in every year but one. His success was so great that at one time more than a quarter of the undergraduates studying mathematics were practically learning all their mathematics from him. His pupils were naturally divided into four "years" by their time of entering the University; and each "year" was subdivided into three or four classes, so that he

had perhaps a dozen classes going at once; and to each class he would talk without hesitation for the allotted hour, rarely forgetting to begin just where he had left off, and seldom making even a slip in working on the blackboard. When it is remembered that he was thus covering the whole range of subjects for the *Tripes*, including ultimately the mathematical physics which had so rapidly developed during his own lifetime, one cannot but marvel at the astonishing memory which retained such a mass of facts in so orderly an arrangement. If at any time in his career all living senior wranglers could have been induced to compete in an Olympic *Tripes*, Routh would surely have been easily first of them all. Some of the lessons he gave were doubtless old and had been repeated many times, but many were new, for Routh kept fully abreast of the times, reading, digesting, and reducing to the form of "a little manuscript, which you had better copy out in the other room," such memoirs as were appearing from day to day. He was teaching almost uninterruptedly from 7 or 8 A.M. till 2 P.M.; after which he took a walk for two or three hours with the utmost regularity, devoting the evening to setting or looking over examination papers for his pupils. This busy life went on through July and August (the "Long Vacation") as well as through the regular terms; but immediately he was free, he got away with his family abroad, or to some complete change of scene. How he managed to find time to write his comprehensive treatises on Statics and Dynamics, and to win the Adams Prize in 1877 by a masterly essay on the "Stability of Motion," must remain a mystery to most of us.

Looking to-day at Routh's notes on Astronomy, one finds little to modify; indeed they have been consulted many times during a dozen years of teaching, and always with profit. The details of a transit-circle have become more familiar to his former pupil than they were when Routh sketched his diagram on the board and briefly enumerated the chief points, but years of added experience do not suggest any essential improvement on Routh's description, which has often been repeated almost verbatim. His quaint little touches of humour are often the quickest route to an explanation. "There is a wheel with sixty teeth," he would say in describing the chronograph, "but one is removed, so there are only fifty-nine." After explaining the method used for planetary aberration by antedating the observation—"Why cannot this method be used for a star?"—he would ask, and then reply, "Because light may take a thousand years to reach us from the star, and during that time the path of the earth is sensibly curved." Those who looked up from their notes at this would catch the little twinkle which impressed the point permanently on their memory. There were quaint expressions in other departments of mathematics which successive generations of pupils learnt to look for. All floating bodies were called ships: "Let us now consider the case of a spherical ship," he would say. His pupils did not see much of him outside the class-room until they had taken their degrees, but some of them were then privileged to form lifelong

friendships with their former tutor. To accompany him on one of his daily walks was to realise a new pleasure in walking. It is perhaps worth recording, though a trivial matter, that he seldom failed to draw attention, when opportunity offered, to the transit-circle mark on Grantchester steeple, pointing out to his companion how it had been placed so as to minimise unsightliness.

When he gave up private tuition in 1888 his former pupils asked permission to have his portrait painted by Herkomer as a present for Mrs. Routh. Mr. Justice Stirling made the presentation in the company of a large number of the subscribers, including 13 senior wranglers.

Dr. Routh was elected a Fellow of the Royal Society in 1872, and served on its Council, 1888-90.

He was elected a Fellow of the Society on 1866 April 13.

H. H. T.

By the death of Mr. HENRY CHAMBERLAIN RUSSELL, C.M.G., B.A., F.R.S., the State of New South Wales has lost its former Government Astronomer and Meteorologist, and Australia one of its most eminent sons. Mr. Russell was the son of the Hon. Bourn Russell, and was born in West Maitland in 1836. He graduated at Sidney University in 1858, and obtained the Deas-Thomson Scholarship for Physics and Chemistry. Immediately on leaving the university he was appointed assistant to Mr. Scott, the Government Astronomer. At the age of 25 he temporarily held this latter post after the death of Mr. Scott, and before Mr. Smalley was appointed. On the death of the latter in 1870, Mr. Russell succeeded to the post and held it for thirty-five years. He at once set about re-organising and re-furnishing the observatory, so that within seven years he had added seven new rooms and a dome, and had replaced the old instruments by modern ones, and throughout his long tenure he kept the observatory in an efficient state. He also turned his attention to meteorology. In 1870 there were 12 meteorological observing stations in the whole State of New South Wales, and the Government could not afford any large contribution towards an increase. Mr. Russell, by his activity, persuasion, and influence, induced the squatters and farmers to make observations of rainfall and evaporation; and by his mechanical ingenuity furnished the stations with the necessary apparatus, with the smallest possible outlay. The result was that when he resigned his post in 1903 there were 1800 stations, and over 90 per cent. were voluntary.

Mr. Russell was chief organiser of the Australian observers of the transit of Venus in 1874. Five Australian observatories took part, and Mr. Russell furnished the report to the Royal Astronomical Society.

By 1876 he had collected all the observations of rainfall and discussed them, with the result that he believed there was a periodicity. In 1878 he had a large number of returns from the observing stations, and after careful analysis was enabled to com-

mence the publication of weather maps in the papers. In 1887, in conjunction with Sir Charles Todd of South Australia and Mr. Ellery of Victoria, he succeeded in establishing a system of weather forecast, the weather changes occurring with an amount of regularity which permits of 82 per cent. of the forecasts being correct. Mr. Russell was greatly interested in the project of charting the heavens by means of photography, and attended the first meeting of the Congress in Paris. The zone -54° to -62° , requiring 1400 plates, was allotted him.

Such are the chief landmarks in two branches of scientific work, and they convey but a poor idea of Mr. Russell's genius and general activity. The picture may be filled in from the following general remarks.

Considering him as an inventor and mechanic, we find a list of 23 instruments designed and in great part made by him, generally with the object of ensuring success in his meteorological endeavours. We can mention only a few:—

A self-recording Anemometer and Pluviometer.

A self-recording Tide Gauge.

An electric Barograph.

Various self-recording Pluviometers.

An Anemometer in which the motion of the vane and cups is conveyed 75 feet vertically to the recording parts, and which also permits rain to drop 65 feet down the centre of a large tube and be recorded on the same sheet as the wind.

A Governor for driving clocks—the governor floating in mercury.

The application or combination of the two pendulums to produce uniform rotary motion.

An Equatorial Stand for the $11\frac{1}{2}$ -inch refractor.

The Equatorial mounting for the 15-inch reflector.

We find that he contributed 130 papers to various societies; and a general idea of the breadth of his interests may be gathered from a selection of his astronomical papers contributed to our Society. To the *Memoirs* he contributed—

“Report of the Transit of Venus,” 1874, vol. xlvii. “Measures of Double Stars,” in Sir J. Herschel's Cape Catalogue, together with a list of 351 new double stars, vol. xlvii. “Measures of Double Stars made at the Sydney Observatory in the years 1882–1889,” vol. l.

And to the *Monthly Notices*—

“On the Australian Eclipse Expedition 1871,” vol. xxxii. “Note on the Nebula surrounding η Argus,” vol. xxxii. “Observations of Comet Brorsen,” vol. xxix. “Observations of the Great Southern Comet of 1880,” vol. xl. “Some Celestial Photographs taken at the Sydney Observatory.” “An Electric Control for a Driving Clock,” vol. li. “Transits of Mercury 1881 and 1894,” vols. xlii., lv.

Mr. Russell took a very active part in initiating technical education, and served as a member of the Board of Technical Education, his services being recognised when in 1891 he was

made Vice-Chancellor of the University of Sydney. He was for several years President of the Royal Society of New South Wales, and we may mention that he was the only graduate of Sydney ever elected to the Royal Society, of which he became a Fellow in 1886. In 1891 Mr. Russell was made Companion of the Order of St. Michael and St. George. In 1903 he had a severe illness, from which he was scarcely expected to recover, and ever since he had suffered from indifferent health; finally he succumbed, in his 71st year, on 1907 February 22. He leaves a widow, with one son and four daughters.

He was elected a Fellow of the Society 1871 February 10.

T. L.

ASAPH HALL was born at Goshen, Connecticut, on the 15th of October 1829. At one time wealthy, the family had become poor, and Asaph Hall was apprenticed to a carpenter. Intending, however, to become an architect, he studied mathematics in his spare time. Finally, in 1856, he entered the University of Michigan and studied astronomy under Dr. Brünnow. Leaving Michigan, he became an assistant at Harvard Observatory, under Bond, where he remained until his transfer to the Naval Observatory at Washington in 1862. In the following year he was made Professor of Mathematics. He was amongst the earliest astronomers to appreciate the value of observations of Mars for determining the parallax of the Sun; his investigations, in 1862, of the solar parallax by this means is his first paper of note. From observations made at Upsala, Santiago, and Washington, he deduced the value of $8''.84$ for the solar parallax. In these early years at Washington he also published *A Catalogue of 151 Stars in the cluster of Præsepe*, and *A Study of Comets Faye and Winnecke*, showing that there was no retardation due to a resisting medium. In 1870 he published in the *American Journal of Science* an interesting paper on the "Secular Perturbations of the Planets." An important paper on the "Determination of Longitudes by Moon Culminations" appears in vol. xxxiii. of our *Monthly Notices*. About this time he was giving great attention to minor planets, both by observation and computation. Thus in the *Astronomische Nachrichten*, 1875, will be found a discussion of the Washington observations of Flora, and in the same publication for 1874 a determination of the orbit of Alceste. Throughout this period, too, he contributed numerous mathematical papers to the *American Journal of Science* and the *Messenger of Mathematics*.

In 1875 he took charge of the 26-inch Washington refractor, and made numerous measures of double-stars, diameters of planets, and distances and positions of satellites, which, with his drawings of Mars and Saturn, appear in the volumes of *Washington Observations*. Sir W. Herschel in 1794 found the rotation period of Saturn to be $10^h 16^m$, and from that time to 1876 no one appears to have made an attempt to verify this time. Professor Hall set this down as one of his tasks, and on December

7, 1876, he was fortunate enough to find near Saturn's equator a bright spot. This he followed for sixty rotations, and was enabled to fix its period of rotation as $10^h 14^m 24^s$, a value which has subsequently been found by other observers. It will thus be seen that Asaph Hall was an excellent observer, and fully alive to the needs of astronomy. It is not surprising, therefore, that, being equipped with so powerful an instrument as the 26-inch Washington refractor, he should decide in 1877 to begin a systematic search for possible satellites of Mars. On August 11, the second day of his work, he discovered an object which he suspected to be a satellite. Bad weather intervening, he did not obtain another chance till August 16, when his suspicions were confirmed; on the following night, while watching for the satellite, he found a second moon nearer to Mars. The quick movements of this inner satellite were perplexing, and, to quote Professor Hall's words, "it would appear on different sides of the planet on the same night; and at first I thought that there were two or three inner moons, since it seemed to me at that time very improbable that a satellite should revolve around its primary in less time than that in which the primary rotates." His observations of August 20 and 21, however, satisfied him that there was but one inner moon. In 1878 he published the orbital elements of these satellites, showing that Deimos completed its revolution in $30^h 17^m 54^s$, and Phobos in $7^h 39^m 14^s$. For his discoveries he received in 1878 the Lalande Prize of the Paris Academy of Sciences. In 1879 Lord Lindsay, as President, presented him with the Gold Medal of our Society for "his discovery and observations of the satellites of Mars, and for his determination of their orbits." In the same year he received the degree of LL.D. from Yale College.

In 1882 Nyérén gave reasons for supposing Struve's constant of aberration should be increased from $20''.445$ to $20''.492$, which, combined with Newcomb's determination of the velocity of light, gave $8''.794$ as the solar parallax. Loewy, in 1891, had made investigations tending to show that Struve's value should be retained, and at this juncture Professor Hall, from observations of α Lyrae since 1862, had found the value $20''.454$, upholding Struve, and making the corresponding parallax $8''.81$.

Professor Hall devoted much time to the measurement of double-stars; his measures of the companion of Sirius from 1872 to 1888 form a fine series, and give the place of the satellite till its separation from Sirius was only $5''.3$. The whole of his double-star measures are published in two volumes, one containing his work during the years 1875-1880, the other 1881-91. This work led to investigations of the parallax of α Lyrae and of 61 Cygni. He also gave special attention to measuring the diameters of the various planets, and of the distances and positions of their satellites, and, as was the case with all his observations, he followed up the measures with investigations of elements, particularly of Mimas, Enceladas, Tethys, Dione, Rhea, and Titan, which are in Appendix i. of the

Washington Observations, 1883; of Oberon and Titania, the outer satellites of Uranus, in 1881, Appendix i.; while in Appendix ii. he gives a determination of the orbit of the satellite of Neptune, and deduces the mass of Neptune. Finding that most of the measures of Hyperion had been made near one elongation, he made measures in 1875 and 1876 with the 26-inch, and computed an orbit. His mathematical papers were numerous, and covered most astronomical investigations.

Professor Hall had taken part in several observational expeditions, such as—the solar eclipse of 1869 (Behring Straits), of 1870 (Sicily), and of 1878 (Colorado); the transit of Venus of 1874 (Vladivostock) and of 1882 (Texas). In 1891 he retired from the Navy, and in 1896 he was elected to one of the Professorships of Astronomy at Harvard. His death occurred on 1907 November 22. He was elected an Associate of the Society 1879 Jan. 10. T. L.

PIERRE JULES CÉSAR JANSSEN was born at Paris on the 22nd of February 1824. He was descended from a family which originally dwelt at Liège. His father was a well-known musician, and his mother the daughter of an architect of some celebrity in Paris. An unfortunate accident when young, through the carelessness of a nurse, rendered him lame for life. The boy seems to have been endowed with considerable talent, which he at first exercised in drawing and painting. At the age of sixteen he entered into business as a clerk at a bank, in which he remained for seven or eight years, but during this period he devoted his spare time to the study of mathematics, which so absorbed him that he determined to quit business and to study science. He entered the Collège Bonaparte, and about 1850 took his degree as Bachelier-ès-Sciences. Subsequently at the Sorbonne he attended the lectures of Chasles, Cauchy, Lefébure, Le Verrier, and Sturm, and in 1852 received the degree of Licentiate of Mathematical Science, and later on that of Physical Science.

At the early part of Le Verrier's direction of the Paris Observatory, Janssen was with him as a computer; but the occupation not being very congenial to him, he did not long remain at the observatory, and for the next two years he became Assistant Professor of Mathematics at the Lycée Charlemagne.

In 1856 he made a tour in Turkey, Asia Minor, and Egypt, and in 1857-58 he undertook a scientific expedition to Peru to investigate and determine the position of the magnetic equator. In this he was assisted by his pupils Ernest and Alfred Grandidier. Unhappily he was seized with serious illness, from which he nearly died, and which compelled him to abandon the enterprise, and to sail for Europe to recover his health.

Soon after his return to France he commenced those researches that have made the name of Janssen illustrious in the domain of Solar Physics.

His first published scientific paper appeared in the *Comptes Rendus* for 1860, under the title "Sur l'absorption de la chaleur

rayonnante obscure dans les milieux de l'œil," in which he showed the relative proportion of heat rays which are absorbed by the cornea, the aqueous humour, the crystalline lens, and the vitreous humour, and proved that only a small percentage of such rays reach the retina.

At this time the brilliant researches of Kirchoff and Bunsen had strongly attracted the attention of physicists, and Janssen determined to devote himself to some of the problems that had been indicated by spectrum analysis. In 1860 Brewster and Gladstone had demonstrated the existence of atmospheric bands in the solar spectrum. But so far back as 1832 the former had found that certain dark lines which were invisible with a high sun became conspicuous as it approached the horizon; and in 1856 Crookes had called attention to the fact that the atmosphere absorbed a great part of the more refrangible rays.

In 1862 Janssen established an observatory at Montmartre for the purpose of investigating the absorptive influence of the atmosphere. By means of a powerful spectroscope composed of five prisms he succeeded in resolving the dark bands into fine lines, which he found to vary in intensity directly as the altitude of the Sun, being darkest at sunrise and sunset. This established their atmospheric origin, and Janssen accordingly named them "telluric lines." The results were published in the *Comptes Rendus* for 1862.

In order to confirm these important observations he determined in 1864 to make experiments from the summit of the Faulhorn, when he was able to convince himself that the telluric lines were fainter there than at sea-level. Subsequently, at Geneva, on examining with the spectroscope the light of a bonfire at Nyon, a distance of thirteen miles, he at once perceived several of the telluric lines which he and others had observed in the spectrum of a low sun. Further researches on this point in 1866 enabled him to establish the fact that most of these absorption lines are produced by aqueous vapour.

In 1867 Janssen was sent by the Bureau des Longitudes to Italy to observe the annular eclipse of the Sun, his object being to make careful comparison of the spectra of the limb and centre of the Sun. As the light of the limb has to pass through a greater thickness of the solar atmosphere, it was expected that the absorption lines there would be strengthened, but the results obtained were purely negative.

In 1868 he was delegated by the Académie des Sciences and the Bureau des Longitudes to proceed to India to observe the total solar eclipse of August 18 in that year.

He was provided with four telescopes of 6 inches aperture with spectroscopes of different optical power, and he established his observatory at Guntoor. On mounting his instruments he found that the case of spectroscopes had been carried off by mistake and could not be available for the eclipse, but his foresight had provided one supplementary spectroscope, which was all he had at his disposal on the critical day.

Several expeditions had been organised for this eclipse, for the purpose of making spectroscopic observations of the solar prominences. All were successful in observing bright lines in the prominence spectra, and thus establishing their gaseous nature.

In his report on the eclipse, Janssen wrote: "Pendant l'obscurité totale je fus extrêmement frappé du vif éclat des raies protubérantielles; la pensée me vint aussitôt qu'il serait possible de les voir en dehors des éclipses." Pursuing this idea on August 19, the day following the eclipse, he succeeded in making those memorable and historic observations which gave astronomers the new method of observing the solar prominences without the aid of an eclipse. With the slit of the spectroscope placed radially, partly on the Sun's disc and partly beyond, he swept a portion of the limb, observing the C line. His words are: "J'étais depuis peu de temps à étudier la région protubérantielle du bord occidental quand j'aperçus tout à coup une petite raie rouge, brillante de 1 à 2 minutes de hauteur, formant le prolongement rigoureux de la raie obscure C du spectre Solaire. En faisant mouvoir la fente du spectroscopie de manière à balayer méthodiquement la région que j'explorais, cette ligne persistait, mais elle se modifiait dans sa longueur et dans l'éclat de ses diverses parties, accusant ainsi une grande variabilité, dans la hauteur et le pouvoir lumineux des diverses régions de la protubérance."

Writing on September 6, 1868, he says: "c'est le 19 août que j'ai fait cette découverte, aussi la véritable éclipse a eu lieu pour moi le 19 et non le 18. Depuis j'ai pu tracer jour par jour la figure, la place, la composition des protubérances du Soleil visibles seulement jusqu'ici pendant les éclipses. Je lis dans un livre fermé jusqu'ici pour tous."

Janssen's report, dated September 19, was read at the meeting of the Académie des Sciences on October 26, 1868, and immediately following it was read a communication from the present Sir Norman Lockyer announcing his independent successful discovery of the same method of viewing solar prominences without an eclipse as that made by Janssen. The Académie des Sciences struck a medal in honour of the discovery, bearing the effigies of both astronomers, and the eloquent words of M. Faye on the occasion may be fitly quoted: "Mais au lieu de chercher à partager, et par conséquent à affaiblir le mérite de la découverte, ne vaut-il pas mieux en attribuer indistinctement l'honneur entier à ces deux hommes de science qui ont eu séparément, à plusieurs milliers de lieues de distance, le bonheur d'aborder l'intangible et l'invisible par la voie la plus étonnante peut-être que le génie de l'observation ait jamais conçue?"

The new field thus opened for the study of Solar Physics at once led the French Government to consider the question of establishing a suitable physical observatory for Janssen. The question was seriously delayed by the war, and it was not till September 1874 that the Académie des Sciences could report on the subject. A provisional observatory was first established at

Montmartre, but eventually it was decided to utilise the Château de Meudon, where Janssen took up his residence in October 1876. In the meantime Janssen had undertaken several solar eclipse expeditions. In 1870, during the siege of Paris, he made his memorable escape in a balloon to observe the eclipse of December 22 at Oran, where the weather, however, prevented all observations. In 1871 he went to India and established himself in the Neilgherry Hills. He employed a specially constructed reflecting telescope, the mirror of which was 15 inches diameter, and had a focal length of only 56 inches. A direct vision spectroscope of ten prisms was employed. With the brilliant spectrum such an instrument gave he observed some of the Fraunhofer lines in the continuous spectrum of the corona, and was also able to determine that the green 1474 line in the corona was not visible in the spectrum of the prominences. He also went to India to observe the eclipse of 1875 April 6.

In 1874 he undertook an expedition to Japan to observe the transit of Venus.

In order to secure a photograph of the actual geometrical contact he invented the "Revolver Photographique," an instrument which takes a series of photographs at short intervals of time precisely on the principle of the cinematograph, of which it is indeed the forerunner.

It is from this period that those researches of Janssen's in solar photography date which have culminated in the remarkable "Atlas de Photographies Solaires," published in 1903. At the commencement of work at the Meudon Observatory, Janssen erected a special instrument for photographing the solar surface. It consisted of a telescope of 5 inches aperture, with a suitable enlarging lens which allowed him to obtain an image of the Sun from 12 to 18 inches diameter. In the optical construction of it he utilised the fact that there exists in the spectrum, near the Fraunhofer line G, a narrow band of rays which possess a photographic activity upon the salts of silver much more intense than that of any other portion of the spectrum; so that if the exposure be very short and properly regulated, the effect is practically the same as if the sunlight were monochromatic, consisting of these rays alone, and any defect in the correction for chromatic aberration in the lens is rendered almost harmless. With this telescope, and with exposures so small as from $\frac{1}{1000}$ to $\frac{1}{3000}$ of a second and even less, Janssen obtained that marvellous delineation of the solar surface which is so well known from the published results. He described all his methods in a very complete paper on the subject in the *Annuaire du Bureau des Longitudes* for 1879. The first significant discovery he was able to announce was that of the "Réseau Photosphérique," by which term he designated certain hazy, smudgy patches in the granular surface of the photosphere, which, in his opinion, showed continual agitation and change in the solar atmosphere. Employing this apparatus in photographing a partial eclipse of the Sun, he showed that not the slightest distortion

in the solar granules could be detected up to the limb of the Moon, and by this most delicate test any evidence of the existence of a lunar atmosphere was completely negatived.

Though the Château de Meudon had been in a great measure destroyed by the siege of Paris, yet the stables, nearly 100 metres long, remained intact, and were formed by Janssen into a very suitable laboratory for the study of absorption spectra, the divisions of the stalls forming excellent supports to the lengthy tubes he employed.

Jules Janssen was endowed with great energy, courage, and determination, which in no case are shown more conspicuously than in the ascents he made of Mount Blanc for the purpose of making spectroscopic observations in the higher strata of the atmosphere. He made two ascents, in 1893 and 1895. His lameness prevented him from walking, and consequently he was carried by porters from Chamounix to the summit—a quite unique performance. But this enabled him to arrive at that high altitude with a mind and body unwearied by physical exertion, and thus able to devote himself under the most favourable circumstances to the observations he proposed to make, and also to plan out an observatory on the summit. One of his principal objects was to determine the presence or not of oxygen in the Sun. He accordingly made his ascent in winter, so that the influence of aqueous vapour in the atmosphere might be at a minimum. His observations negatived the existence of oxygen in the solar atmosphere, though recent observations are of a more positive character.

His unwearied activity throughout his life is shown by the numerous contributions to the *Comptes Rendus*, the *Annales de Chimie*, and many other scientific publications.

In 1873 Janssen was elected a member of the Académie des Sciences and the Bureau des Longitudes. In 1875 he became a Foreign Member of the Royal Society, who in 1877 gave him the Rumford Medal. The Academies of Rome, St Petersburg, Edinburgh, Brussels, and Washington did honour to him by electing him as one of their corresponding members.

A cold caught last December developed into congestion of the lungs, from which he died on the 23rd of that month, leaving a devoted wife and daughter to mourn the loss of one who will always rank as one of the most eminent scientific men of his country. He was elected an Associate 1872 Nov. 8. E. B. K.

MAURICE LOEWY was born of Jewish parents at Vienna on April 15, 1833. He was educated at the Polytechnic School and at the University of Vienna, and received his astronomical training at the Imperial Observatory under the directorship of von Littrow. His first contribution to astronomical literature is in the *Sitzungsberichte* of the Vienna Academy for April 16, 1857, and consists of a determination of the elements of the minor planet Leda then just discovered. Other computations of a similar character followed, including one of the elements of Donati's comet.

In August 1860 he accepted an invitation of Le Verrier's to the Paris Observatory, and in the volume of Paris observations for 1861 the initials M. L. are frequently found against the observations made with the meridian circles, the circle of Gambey, and the equatorials. In 1864 he became naturalised, and in 1870 served his adopted country on the ramparts of Paris.

His interest in minor planets and comets continued. In particular he made several investigations of the orbit of Eugenia, allowing for the perturbations. In 1872 he published a theoretical paper for simplifying and expediting the computation of orbits, with a number of subsidiary tables.

M. Loewy's attention, as was to be expected in so skilful an observer, was attracted to the details of the meridian circle. By means of an optical apparatus in the central cube he devised a method of determining the flexure of the telescope at various zenith distances. With the same apparatus he was able to investigate the errors of the pivots. He also developed a method of observation of close polar stars at various points in their circular paths, which he applied to various problems of fundamental astronomy, such as the determination of latitude without using the declinations of fundamental stars, and the determination of right ascensions without relying on the right ascensions of the circumpolar stars. This interest in the details of meridian work continued to the end of his life, a paper which he passed for press shortly before his death being an account of a new method he had devised for determining the errors of a divided circle.

In 1871 M. Loewy prepared his new form of equatorial, to which the name of "Equatorial Coudé" was given. Delaunay, who was at that time Director of the observatory, was much impressed by the possibilities of this form of instrument, but owing to his death the project of constructing one was not carried out. The first instrument of this type was completed in 1882, and had an object-glass of $10\frac{1}{2}$ inches. This form of mounting is now so well known that it is not necessary to say more than that by reflection at two plane mirrors light from any part of the sky is directed into a fixed direction—that of the polar axis. The inconveniences which an observer with an equatorial must put up with are avoided. The observer can direct the instrument to any object without moving from his chair, and his observations are made under the most favourable conditions for his own comfort, similar to those under which the microscope is used by the student of natural history.* The possible drawbacks of this form of mounting are the loss of light at the two reflections and the possible flexure of the mirrors. The latter was avoided by making the mirrors thicker than was usual at that time. The performance of the coudé in the separation of double stars, and still more in the beautiful series of photographs of the Moon taken by Loewy and Puiseux, shows that the definition does not suffer appreciably by the two reflections.

* See Address delivered by the President, Mr. W. H. M. Christie, on presenting the Gold Medal of the Society to M. Loewy, *M.N.*, vol. xlix. p. 248.

M. Loewy's method of determining the constant of aberration is developed in a series of papers to the Academy of Sciences in the years 1886 and 1887. The peculiar liability of this constant to be affected by systematic error in the observations makes the differential method devised by M. Loewy of special value. By the ingenious device of a double mirror formed by silvering two faces of a prism placed in front of the object-glass, and capable of rotation about the axis of the telescope, he was able to view simultaneously two stars in widely different parts of the sky. The distance between two such stars is affected by aberration, and by observing this distance when the stars are at the same altitude, and again, three months later, when they are in the same position, a determination of the constant is obtained. The advantages of the method are that a comparatively large coefficient is involved, that errors due to precession and nutation are absolutely eliminated, and those due to refraction reduced to a minimum. By varying the conditions the same method of observation can be applied to determine the refraction, and it was for this purpose the instrument was originally constructed. The complete theory of the instrument, including the effect of temperature, change in the position of the axis round which the double mirror turns, the most suitable angle of the prism, and the choice of stars, are all carefully dealt with by M. Loewy. His theoretical conclusions as to the freedom of the instrument from systematic error were justified by experience; and though the results which were anticipated have not been realised as yet, the method constituted a new departure of great value. In this instrument, as well as in the equatorial coudé, M. Loewy has placed at our disposal methods of observation based on entirely new principles, and calculated to give astronomers improved and quite independent means of attacking several of the most important problems in our science.*

M. Loewy was elected a member of the Academy of Sciences in 1873, succeeding Delaunay. In the previous year he had been appointed a member of the Bureau of Longitudes. With Admiral Mouchez he instituted the Observatory of the Bureau of Longitudes in the Park Montsouris for the instruction of sailors and explorers. The determination of the difference of longitude between Paris and the cities of Berlin, Vienna, Algiers, and Marseilles are his own personal contributions to Geodetic Astronomy. For thirty years he edited the *Connaissance des Temps* and the astronomical part of the *Annuaire du Bureau des Longitudes*.

In 1878, when Admiral Mouchez became Director of the observatory, M. Loewy was made Assistant Director, and he held the same position under Tisserand whom he succeeded as Director in 1896. During this time the project for the International Photographic Chart and Catalogue of the Heavens took shape, a project to which the Paris Observatory contributed the optical skill of the brothers Henry and the organising ability of Admiral Mouchez. M. Loewy

* See Address delivered by the President, Mr. W. H. M. Christie, on presenting the Gold Medal of the Society to M. Loewy, *M.N.*, vol. xlix. p. 248.

interested himself in the details of this work from the start, and conducted researches on the best methods of measurement of the plates, and the derivation from the measures of the accurate positions of the stars. He also concerned himself with the reproduction of the chart plates, and inaugurated the publication on paper of enlarged copies of the original negatives. In his later years the two pieces of work to which he devoted greatest attention were the photographic atlas of the Moon, and the organisation and execution of the observations of Eros for the determination of the solar parallax. The photographs of the Moon, taken in collaboration with M. Puiseux, are of the greatest beauty and value. The coudé telescope being of long focus, gave an image of the Moon on a large scale, and this was subsequently further enlarged. An immense amount of care and labour was required to obtain photographs with such fine definition, not above one plate in ten, though taken in apparently good atmospheric conditions, being considered by the critical authors as sufficiently good for publication. This atlas gives a permanent record of the minutest details of the Moon at the present epoch; and should any changes occur, they will be detected by comparison of photographs taken in the future with those contained in the atlas of Loewy and Puiseux.

The Eros campaign, which was decided upon by the Astrographic Conference which met at Paris in 1900, brought a large amount of work, which he did not in the least shirk, upon M. Loewy. He undertook and carried out the preparation of ephemerides, the selection of reference stars, and the collection and publication of the results obtained at the different observatories. At the same time he obtained results of the highest degree of accuracy from the photographs taken at the observatory which he directed. He made extensive investigations of the precision which could be obtained by repeating the measures under different conditions; and if he erred at all, it was in having the plates measured with more care rather than with less than they required.

M. Loewy was a corresponding member of the Academies of St Petersburg, Vienna, Berlin, Rome, and Washington. He received the Gold Medal of the Royal Astronomical Society in 1889 for his invention of the equatorial coudé and his method of determining the constant of aberration. The conferences at Paris brought him in contact with astronomers from all countries. All who met him were impressed by his kindly disposition and his zeal for his work.

M. Loewy died suddenly on October 15 while speaking at a meeting of the Council of the French Observatories. He leaves a widow, two sons and four daughters. He was elected an Associate of the Society 1886 November 12.

F. W. D.

M. CHARLES TRÉPIED, Director of the Algiers Observatory, died suddenly on 1907 June 10, a few days after his return from the *Conférence Internationale des Études Solaires* held at Meudon in May last. On eclipse expeditions, at the successive meetings of

the international conferences for the execution of the Astrographic Chart and Catalogue, and at the recent Meudon conference, he had made many friends among English astronomers, who would wish to join in the tribute paid by the late Monsieur Loewy to the high qualities of heart and mind which gained him "les sympathies de tous ceux qui avaient eu l'occasion de l'approcher, la chaude amitié de tous ceux qui avaient eu le privilège de vivre dans son intimité."

Born in 1844, M. Trépied was associated early in his scientific career with the *Bureau des Longitudes* and its observatory at Montsouris, and he was nominated a member of the Bureau in 1877. About this time the French Government was actively engaged in the organisation and equipment of the six *Observatoires astronomiques de province*, and in 1880 they confided to M. Trépied the directorship of the Algiers Observatory, with the task of re-creating it upon a new site. The annual reports to the Ministry of Public Instruction from 1880 to 1896 give a very interesting account of the enterprise. Starting with inadequate instruments and a small budget which allowed only one assistant, M. Trépied devoted himself at first to the observation of the places of the Moon and of moon-culminating stars, and to solar spectroscopy. In 1882 he travelled to Egypt to observe at Sohag the total eclipse of short duration in which "les astronomes anglais, italiens, et français avaient résolu de partager fraternellement les opérations."

In 1885 the Algiers Observatory was transferred to Bouzaréah on a height overlooking the city, and in the course of a few years it was equipped with a new meridian circle, equatorial coudé, and astrographic telescope. The volumes of the *Comptes Rendus* bear continual testimony to the activity of the observatory on many sides: its most conspicuous enterprises include a zone of the Southern A.G. Catalogue, a zone of the Astrographic Chart and Catalogue, and a very considerable share in the photographic observations of Eros.

In 1900, when the line of totality passed over his observatory, and again in 1905, when it passed over Guelma, M. Trépied earned the gratitude of several British eclipse observers by his whole-hearted devotion to their help. And the same kindly qualities which were so conspicuous on these occasions made him the man upon whom was naturally thrust the burden of acting as Secretary to every meeting of the Astrographic Conference; to the Conference of Directors of National Ephemerides which met at Paris in 1896; to the Meudon Conference of 1907; and to many others. In this position he was able on many occasions to exercise his power of polite but acute criticism. "La règle est précise; cependant il est aisé de voir que la précision est toute dans les termes, non dans le fond," was his verdict upon the resolution which bound the observatories to get fourteenth magnitude stars upon their charts at a date when there was even less possibility of defining exactly the fourteenth photographic magnitude than there is now.

A like elegance distinguished his mathematical investigations

in geodesy, where he extended Legendre's theorems on the treatment of large spherical triangles; in celestial dynamics; and especially in the theory of precise celestial photography, to which he contributed formulæ of great generality, and at the same time great convenience.

The untimely death of M. Trépied is one of the heaviest of the great misfortunes which have robbed France within the last few years of nearly all the men who bore so distinguished a part in the inception and development of the great enterprises in which French astronomy has been involved.

He was elected an Associate of the Society 1901 November 8.

A. R. H.

HERMANN CARL VOGEL, the announcement of whose death on August 13, 1907, was everywhere received with profound regret, will always occupy a high place in the history of astronomy as one of the pioneers in the new fields of inquiry opened up by the application of the spectroscope to the study of the heavenly bodies. He was born at Leipzig on April 3, 1841, and, while yet a student at the university, was appointed as assistant at the observatory in that city in 1865. During the preceding three years a great impetus was given to spectroscopic astronomy by the striking results which had been obtained by Rutherford in America, Secchi in Italy, and Huggins in England, and there can be little doubt that at this time Vogel was especially attracted by the great possibilities which the work of these observers suggested. He was probably still further influenced at a little later stage by the discovery of the method of observing solar prominences without an eclipse which was made by Lockyer and Janssen in 1868, and by the first researches of Huggins on the movements of stars in the line-of-sight. At all events, after taking his degree in 1867, we find him to have been actively engaged with Zöllner in 1869 in the observation of solar prominences, and from this time to his death his energies were chiefly directed along astrophysical lines of research.

The record of Vogel's work at the private observatory founded by von Bülow at Bothkamp, of which he was in charge from 1870 to 1874, is the best possible testimony to his great skill and industry in the earlier part of his career. From the well-known publications of the observatory during this period we see that his outlook was already a wide one; the spectra of the Aurora, the Zodiacal Light, and lightning received his careful attention, no less than those of the Sun, stars, star clusters, nebulae, comets, and planets. For these observations he employed a spectroscope which he had specially designed to secure the stability which is essential to useful work on the motions of the stars, and for the determination of wave-lengths with reasonable accuracy. The results of some of these observations have naturally been superseded by others which have since been made with more powerful instruments, but they were of the highest order for the period, and Vogel was himself always among the first to devise and employ improved methods of observation.

Among the more notable of Vogel's achievements at Bothkamp were the spectroscopic determination of the Sun's rotation, and his classical work on the spectra of planets. Employing a "reversion spectroscope" of the form designed by Zöllner, he indeed obtained the first spectroscopic proof of the Sun's rotation by the opposite displacements of the solar lines at the east and west limbs, and at the same time established the truth of the Doppler principle on which the determination of velocities is based.

The successful work at Bothkamp, in conjunction with that of Spörer, was chiefly instrumental in securing the foundation by the Prussian Government of the present Astrophysical Observatory at Potsdam, the erection of which was commenced in 1874. Vogel was immediately appointed as an observer, and, in 1882, on the observatory passing from the control of the commission at first in charge of the work, he was promoted to the responsible post of Director. It is generally acknowledged that his administration of this important observatory, intended for the advancement of what was practically a new science, and bound by no traditions, has been completely successful in establishing and maintaining a high standard of accuracy in all its numerous undertakings.

Vogel early recognised the importance of preparing a spectroscopic catalogue of the stars on a more extensive scale than had been previously attempted, and, with the assistance of Dr. Müller, in the years 1880 to 1882, he catalogued the spectra of all the stars down to magnitude 7.5 in the zone -1° to $+20^{\circ}$, the total number amounting to 4051. The classification adopted was that proposed by Vogel in 1874, being an extension of Secchi's system, and definitely introducing Zöllner's idea that the different spectra exhibited by the stars depend upon the temperatures which they have reached in a general evolutionary process. In 1895 this classification was further extended so as to take account of the additional features revealed by photographic spectra; and though not universally adopted in detail, its leading principle is embodied in other classifications which have been put forward.

No material advance in the investigation of stellar motions was made until the introduction of the photographic method by Vogel at Potsdam in 1887. The various sources of error which were liable to influence the minute displacements of the lines were thoroughly investigated, and during the next three years the labours of Vogel and Scheiner set this department of astrophysics on a firm foundation. The results were consistent and accurate to an unexpected degree, as was shown by the agreement between the displacements found in the spectra of the Sun and Venus with those resulting from direct calculation. The velocities of 51 stars thus determined were published in 1892 (see *M.N.*, vol. lii. pp. 87 and 541), and an important deduction was that the average line-of-sight velocity — 16.5 kilometres per second — was much smaller than had been previously supposed.

Two results of special interest followed from the spectrographic work during this period, namely, the well-known con-

firmation of Goodricke's explanation of the variability of *Algol* by periodic eclipses produced by a revolving dark companion, and the discovery that *Spica* is a similar system in which the plane of revolution does not pass through the Sun. The interesting facts relating to the dimensions and masses of these systems have passed into the general literature of astronomy and need no further comment, except to recall that, according to Campbell, no less than one in seven of the stars which have been sufficiently observed have since been found to be similarly accompanied by relatively dark bodies. The provision for such investigations at Potsdam was greatly augmented in 1899 by the erection of a telescope of $31\frac{1}{2}$ -inches aperture; and though Vogel's health failed in the year following, the work has been energetically carried on with marked success.

Dr. Vogel's name is associated with other pieces of work of great magnitude which have been carried out at Potsdam under his superintendence. He took an important part in the initiation of the International Chart of the Heavens in 1887, and undertook the zone $+31^{\circ}$ to $+40^{\circ}$ as the Potsdam contribution to this great work. He did not live to see the completion of this task, but all the necessary photographs have been secured and four volumes of results have been published.

Another notable undertaking at Potsdam was the precise photometric determination of the brightnesses of all the stars not recorded as fainter than magnitude 7.5 in Argelander's *Durchmusterung*. In the capable hands of Doctors Müller and Kempf this has been brought to a successful conclusion, and is characterised throughout by the extreme care which has been taken to secure the greatest possible accuracy. The General Catalogue, issued in 1907, refers to no less than 14,199 stars.

Dr. Vogel also made valuable contributions to our knowledge by his careful studies of "New Stars," and by his investigations of the absorption of the solar atmosphere for light of different wavelengths. Mention may also be made of an important series of observations of the positions of nebulae and clusters which he made at Leipzig, with a special view to their future use in the investigation of possible changes.

No less than nineteen learned societies in various parts of the world showed their appreciation of Dr. Vogel's services to science by electing him as honorary member, and, in addition, he was awarded the Gold Medal of the Danish Academy in 1874, the Valz Prize of the Paris Academy in 1891, the Henry Draper Gold Medal of the U.S. National Academy of Sciences in 1892, the Gold Medal of the Royal Astronomical Society in 1893, and the Bruce Gold Medal of the Astronomical Society of the Pacific in 1905. In 1895 he received the honour of the Prussian Order of Merit, and was nominated Privy Councillor of Germany four years later.

This brief notice of a great career cannot be more fittingly closed than by quoting some of the concluding remarks made by Mr. Knobel on the presentation of the Society's Gold Medal to Dr.

Vogel in 1893: "It is a record of unwearying perseverance to accomplish great work ; moreover it is the chronicle of a masterly attainment of success. . . . Not only is astronomy enriched by a series of investigations of the greatest value, but a distinct, and indeed marvellous, advance is made in our knowledge and conception of the stellar universe."

He was elected an Associate of the Society 1882 November 10.

A. F.

PROCEEDINGS OF OBSERVATORIES.

*Royal Observatory, Greenwich.**(Director, Sir William Christie, K.C.B., Astronomer Royal.)*

Transit-circle.—During the year 8648 observations of transits and 7877 of meridian zenith distances have been obtained. The Sun has been observed 167 times and the Moon 107 times. The lunar crater Mösting A has also been observed 55 times. There have also been observed 262 reflexion observations of stars.

The reductions for the Second Nine Year Catalogue for 1900 are nearly completed and the copy for press is nearly ready.

Altazimuth.—This instrument has been used, as before, as a meridian transit instrument during the second and third quarters of the lunation, for the observation of the Sun, Moon, planets, and the stars in Newcomb's Fundamental Catalogue. The instrument is reversed every two months, alternately by reversing in its Ys, and by turning the instrument through 180° of azimuth.

The total number of meridian transits obtained during the year is 1192, including 77 of the Moon's limbs and 43 of the lunar crater Mösting A. The number of extra-meridian observations of the Moon obtained during her first and last quarters is 27.

A new method of illuminating the field was introduced in June. The small prism cemented to the centre of the object-glass reflecting the light of an electric lamp placed at one side of the glass was replaced by an elliptical reflector with a matt surface of opal glass cemented in the same position, making an angle of 45° with the object-glass; the minor axis of the ellipse is 1.5 inches, the major axis $\sqrt{2}$ times this. This gives uniform illumination over the field, and the wires are much better defined, the small pencil of light from the prism having given rise to diffraction effects.

Reflex zenith tube.—During the year 1638 double observations and 37 single observations have been obtained. γ Draconis was observed on 80 days, β Draconis on 57 days, and ϵ^2 Cygni on 48 days.

It is proposed to discuss the observations of the year 1903 to 1907 together, for determination of the mean places of the stars and the variation of latitude.

Occultations.—During the year 28 disappearances and 2 reappearances of stars occulted by the Moon have been observed by one or more observers. The results have already been communicated to the Society.

28-inch Refractor.—The working catalogue of double stars was that brought into use in 1906. This catalogue contains all the G. W. Hough stars, about 500, within the working zone, and a number of miscellaneous pairs.

An analysis of the observations gives—

G. W. Hough Stars.

18	under	0.5	separation
20	between	0.5	and 1".0
25	„	1.0	„ 2.0
90	over	2.0	separation

Miscellaneous Stars.

56	under	0.5	separation
52	between	0.5	and 1".0
54	„	1.0	„ 2.0
91	over	2.0	separation

Of the 500 Hough stars within the limit of declination, 325 have been measured in 1906 and 1907.

κ Pegasi was observed on 15 nights, δ Equulei on 13 nights, and 70 Ophiuchi on 16 nights in 1907.

The equatorial and polar diameters of Jupiter were measured on 13 nights with the bi-filar micrometer, and also with the double-image micrometer.

Thompson Equatorial.—With the 26-inch refractor the following photographs have been obtained:—

Neptune and Satellite,	42	photographs on	18	nights.
Jupiter for position,	11	„	8	„
Saturn „	27	„	17	„
Mars „	8	„	5	„

With the 30-inch reflector the following photographs have been obtained:—

<i>J vi.</i>	Opposition, 1906-7,	25	photographs on	13	nights.
	in 1907,	8	„	6	„
<i>J vii.</i>	„ 1906-7,	7	„	4	„
	in 1907,	3	„	3	„
Saturn <i>ix.</i>	<i>Phæbe,</i>	16	„	16	„
Comet <i>d</i>	1906,	1	„	1	„
	<i>g</i> 1906,	1	„	1	„
	<i>d</i> 1907,	15	„	13	„
	<i>e</i> 1907,	12	„	8	„

In addition to the photographs of Comet *d* 1907 mentioned above, 17 photographs with long exposure for the tail were taken, several of which are of great interest.

104 photographs of 38 minor planets were also obtained. These photographs were all taken for determination of position.

Besides these, 3 long exposures were made in an unsuccessful search for Halley's Comet, and a few others for instrumental adjustments.

As regards the measurement of photographs and reductions,—

The photographs of Neptune and Satellite are measured and discussed as far as the end of the last opposition, and the results published. The photographs of *J vi.* and *J vii.* for the opposition 1906–7; Saturn *ix.* *Phæbe* 1907; the photographs of Jupiter and Saturn for positions; Comets *d* 1906, *e* 1906, *g* 1906, *d* 1907, and the minor planets photographed in 1905 and 1906, have all been measured and published. The measures of minor planets photographed in 1907 are in hand.

Astrographic Equatorial.—Work with this instrument has still mainly been confined to replacing chart plates, which, though satisfactory in other respects, are, owing to slight photographic defects, unsuitable for production of enlarged prints. During the year, 164 chart plates, 7 catalogue plates, 5 of the field round Saturn, 3 of the Pleiades, 8 of minor planets, and 4 of Comet *d* 1907 were taken. Of the chart plates, 72 were rejected, 33 of them because the exposure was interrupted by cloud, or because they did not come up to the standard in showing faint stars; the large number of other rejections is due partly to an accident to the réseau printing frame, on account of which the réseau lines were printed askew on the plates.

Apart from the long exposure plates, the main work of the branch during the year has been the computation of constants for the plates which form the catalogue. Standard co-ordinates deduced from the places of the reference stars in the Greenwich Second Nine Year Catalogue 1900, now in course of preparation, have been computed for the plates of the zones declination 72° to 75° and 81° to 86° . The scale value and orientation having been computed for these plates, and a mean scale value adopted for the whole series, final adopted constants were computed for all the plates of the zones 72° to the pole, 645 in all.

These constants are included in the Introduction to volume ii. of the Greenwich Astrographic Catalogue, which has been prepared during the year and is in type. This volume will be distributed shortly. The recomputation of the constants of the plates in volume i., with standard co-ordinates deduced from the final places of the reference stars in the Greenwich Catalogue above mentioned, has been begun. The computation of scale value and orientation of the 204 plates in zones 69° to 71° is completed.

Enlarged reproductions of 206 chart plates have been made during the year. The total reproduced to December 31 is 744, the ten zones 65° to 74° being complete, and more than a quarter of the four zones 75° to 78° .

Photoheliograph.—Photographs of the Sun have been taken on 214 days during the year 1907, the Thompson photoheliograph of 9 inches aperture having been used alone on 206 days, the Dallmeyer photoheliograph of 4 inches aperture alone on 3 days, and both instruments on 5 days. Of the photographs taken, 486 have been selected for preservation, including 16 with double images of the Sun for determination of the zero of position of the wires.

Photographs have been received through the Solar Physics Committee from Dehra Dûn, India, up to 1907 December 25, and these have been further supplemented by photographs from the Observatory at Kodaikānal, India, and from the Royal Alfred Observatory, Mauritius. The daily record thus made up is complete, for the year 1907, up to 1907 December 25, the date of the last photograph received from Dehra Dûn. The last photograph received from Kodaikānal is dated 1907 August 12, and the last from Mauritius 1907 January 26. The photographs taken at Greenwich have been measured up to 1907 May 21, those from Dehra Dûn up to the end of May, those from Kodaikānal and from Mauritius as far as they have yet been received.

The solar activity throughout 1907 has shown no diminution as compared with the previous year, the months of January and February being indeed two of the most active during the whole of the present maximum. The work of measurement and reduction, therefore, still continues to be very heavy.

The copy for press of the photoheliographic results for 1906 is complete for the daily record, and is in the hands of the printer as far as the end of June. The copy for press of the sun-spot ledger is nearly ready.

During the past year the volume of supplementary photoheliographic results, 1874 to 1885, has been completed and published. The ledgers of the spot-groups, and the computation of the areas of spots and faculæ as "projected," as well as corrected for foreshortening, are therefore now complete from the beginning of the Greenwich photographic record of the state of the solar surface.

Printing.—The copies of the volume of Greenwich Observations for 1905 were distributed in July 1907. The Heliographic Results 1874 to 1885 have been printed, and will be distributed with the second volume of the Astrophysical Catalogue and the Measures of Photographs of Eros for determination of the Solar Parallax, which are just on the point of completion. The printing of the 1906 observations is in progress.

At the request of the Hydrographer, Captain Monro, R.N., and Lieutenant Gibson, R.N., were attached to the observatory from September 16 to October 14 to practise observations with one of the portable transits, in view of a determination of the longitude of the Island of Ascension, and indirectly of the Cape Observatory, to be made in February.

Royal Observatory, Cape of Good Hope.
(*Director, Mr. S. S. Hough, H.M. Astronomer.*)

After twenty-eight years' service as H.M. Astronomer, Sir David Gill retired from the observatory on February 20, and was succeeded by Mr. S. S. Hough, Chief Assistant. The vacancy in the staff thus created was subsequently filled by the appointment

of Dr. J. K. E. Halm, of the Royal Observatory, Edinburgh, to the post of Chief Assistant, who arrived at the Cape on July 1.

Transit-Circles.—The new reversible transit-circle has been in use throughout the year, principally in observations of the list of fundamental stars commenced in January 1905. To this list were added a number of circumpolar stars, and throughout the winter months consecutive transits of the latter, above and below pole, were observed as frequently as circumstances permitted. The method of observing employed has been the Repsold-Struve method, with travelling wire driven by hand.

The discussion of the observations of circumpolars in conjunction with the observations for azimuth determination in the preceding years, while exhibiting unmistakable evidence of the stability of the azimuth marks, indicated a significant and apparently increasing discordance between the azimuth determinations made with Clamp East and those made with Clamp West. Attempts to account for these discordances led to the detection of a slight mechanical defect in the end-bearing of the micrometer-screw, which has now been rectified. Since September 13, observations have been directed to the further testing of the instrument under its altered condition, and to the determination of the personality of observers in observing slow-moving circumpolar stars. These observations appear to indicate that the defects previously shown have now been completely remedied. Regular observation of the Sun and minor planets have been made throughout the year.

The old transit-circle has been employed in observing miscellaneous stars used in connection with the Geodetic Survey of S. Africa, those of which occultations have been observed, or of which places were required for various purposes.

The total number of observations secured with both instruments was as follows:—

Observations of Right Ascension:—

		Reversible T.C.	8-in. T.C.
Number of observations	{ day	726	
	{ night	5226	1788
Collimation by collimators		70	52
" reflexion and reversal		36	
Level		807	121
N. Azimuth Mark		973	
S. Azimuth Mark		1006	

Observations of Zenith Distance:—

Number of observations	{ day	726	
	{ night	4153	1023
Zenith Distance of N. Mark		214	
" " S. "		214	
Runs		318	82
Nadir		716	80
Flexure		51	14

In each case the day observations include observations of the Sun taken on 116 days, observations of Venus on 89 days, and of Mercury on 55 days. The lunar crater Mösting A has been observed on 13 nights with the old transit-circle and on 31 nights with the new transit-circle.

Helimeter.—The systematic observation of the major planets at the time of opposition has been continued and the following observations secured:—

Opposition of Neptune (1907)	. 40 obs. on 5 nights.
„ Mars	50 „ 7 „
„ Uranus	44 „ 7 „
„ Saturn	45 „ 6 „
„ Neptune (1908)*	11 „ 2 „

In connection with the triangulation of the comparison stars used for the planetary observations, 478 measures of distance have been made during the year, and the following zodiacal areas have now been completely triangulated:—

Name of Triangulation.	Limits of R.A.		Limits of Dec.	
	h m	h m	° ' "	° ' "
Jupiter 1904	1 28 to	1 43	+ 6 12 to	+ 10 21
Jupiter 1905	3 49	4 10	+ 17 54	+ 21 2
Neptune 1897-1908, Jupiter 1906 .	5 19	7 4	+ 20 15	+ 25 22
Mars 1899	7 54	8 22	+ 23 16	+ 25 49
Mars 1901	10 11	10 41	+ 13 7	+ 17 15
Jupiter 1898, Mars 1903	12 14	12 45	- 2 8	+ 1 6
Jupiter 1899	14 8	14 23	- 12 55	- 11 13
Mars 1905	14 43	15 15	- 18 59	- 15 37
Uranus 1898-1907, Saturn 1898-1901, Jupiter 1900, 1901 }	15 47	19 8	- 25 7	- 18 13
Saturn 1902	19 40	19 55	- 22 29	- 19 28
Saturn 1903, 1904, Jupiter 1902 .	20 24	21 34	- 21 14	- 14 42
Jupiter 1903	23 10	23 30	- 7 30	- 4 30

During the transit of Mercury of November 14 a series of measures of the distances of Mercury from the Sun's limbs, comprising in all 48 pointings, were secured, and in connection therewith observations of 5 standard pairs for the determination of instrumental corrections were made on 3 nights.

The Victoria Telescope.—This instrument has been almost exclusively used throughout the year in the photography of stellar

* Still under observation.

spectra for the determination of radial velocities and the solar parallax. The instrument was in use on 103 nights, and 231 plates of the spectra of 18 stars were secured. 246 stellar spectra have been measured, mainly in connection with the determination of solar parallax.

The radial velocities of the following stars, specially selected for the determination of solar parallax, are completely reduced and await final discussion:—

α Tauri . . .	25	plates	covering	3	quadratures.
α Orionis . . .	35	"	"	3	"
α Can. Min. . .	34	"	"	3	"
β Geminorum . .	14	"	"	3	"
α Boötis . . .	46	"	"	3	"
α_2 Centauri . .	44	"	"	3	"
α Scorpii . . .	39	"	"	4	"

A considerable number of experimental plates for the examination of the focal adjustments have also been secured and carefully measured. A discussion of these plates has resulted in a distinct improvement in the focal adjustments, while their permanence has been further secured by an improved arrangement for circulating the air surrounding the prism box. Whereas formerly a practically perfect temperature and focal control was secured so long, but only so long, as the instrument remained undisturbed in one position, under the improved circulatory system no appreciable change in focus occurs as the result of moving the instrument from one position to another.

Astrographic Telescope.—This instrument has been chiefly used in the photography of selected regions, in accordance with the plan proposed by Professor Kapteyn. The number of plates secured is as follows:—

Description of Plate.	No. of Plates.	No. of Exposures.	Duration of Exposures.
Kapteyn areas, proper motion plates . . .	56	112	30 ^m , 30 ^m
Kapteyn areas, parallax plates (1st max.) . . .	184	184	30 ^m
" " " (2nd max.) . . .	24	48	30 ^m , 30 ^m
Parallax pilot plates	7	...	various
Catalogue plates	9	27	6 ^m , 3 ^m , 20 ^s
Adjustment plates	8	...	various
Comet Metcalf region	1	1	40 ^m

During the year 199 Catalogue plates, containing 101,136 stars, including 2282 standard stars, have been measured, both in direct and reversed positions of each plate. The total number of plates now measured is 1285, containing about 700,000 star-images, corresponding to nearly 300,000 different stars.

The actual state of the work on December 31 was as follows:—

	Measures of Co-ordinates. No. of Plates.		Rectangular Co-ordinates computed and examined. No. of Plates.	
	Completed.	Outstanding.	Completed.	Outstanding.
- 41°	144	...	144	...
42	144	...	144	...
43	144	...	144	...
44	132	12	132	12
45	143	1	143	1
46	142	2	141	3
47	144	...	143	1
48	144	...	80	64
49	118	2	1	119
50°	30	90	3	117
- 51°	0	120	0	120
	1285	227	1075	437

Plate constants have been derived for plates in zones - 41°, - 42°, and - 43°, and applied to all rectangular co-ordinates in zone - 41°, and to 112 plates in zone - 42°.

Occultations.—Twenty-four separate phenomena of occultation have been observed, viz.—

Disappearances at dark limb	.	.	.	19
Reappearances „ „	.	.	.	5

The observations up to November 14 have been completely reduced and results communicated in advance to Professor Newcomb.

Transit of Mercury.—On the occasion of the transit of Mercury of November 14, in addition to observations with the transit-circle and heliometer, the times of ingress and egress were observed by six different observers with the various equatorials.

Comets.—Comet 1907 *a* was observed with the Victoria telescope on 6 nights, and the results have been communicated to the *Astronomische Nachrichten*. The results of observations of Comet Finlay (*d* 1906) and Metcalf (*b* 1906), made during 1906, have likewise been communicated to the *Ast. Nach.*, and published during the year.

Publications:—

Vol. ii. part 5 of the Cape Annals, containing “Meridian Observations of the Sun, Mercury, and Venus during the years 1884–1892,” and vol. ii. part 6, containing “Results of Occultations observed during the years 1896–1906,” have been passed through the press and issued during the year.

Vol. viii. part 1, containing “Heliometer Observations of the Major Planets during the years 1897–1904,” has been passed through the press and will shortly be issued.

The Cape Catalogue 1905–6, based on meridian observations made with the 8-in. transit-circle during the years 1905–6, and reduced to the equinox 1900, has been printed and issued.

The Cape day-numbers for 1910 have been printed, and copies received at the observatory for distribution.

Mr. Lunt has contributed a note to the Royal Astronomical Society on "The presence of Tin in Stellar Atmospheres."

Meteorological observations, comprising daily records of air-temperature, pressure, wind, rainfall, etc., have been continued throughout the year, and the results, as in previous years, forwarded to the Meteorological Commission, Cape Town.

Seismograph.—The records of the seismograph have been forwarded to Professor Milne, while a duplicate copy, at the request of the German Government, is forwarded to the Consul-General for Germany in Cape Town, for transmission to the central station for the investigation of earthquakes at Strasburg.

Longitude operations.—In connection with a proposed telegraphic determination of the longitude of the Island of Ascension, both from Greenwich and the Cape of Good Hope, during the visit of H.M.S. "Mutine" to Ascension in February 1908, Mr. Pett, after leave of absence in England and before his return to the Cape, proceeded to Greenwich and observed on 11 nights for comparison of his personal equation, both with the Greenwich observers and with Captain Monro, R.N., who will conduct the field operations at Ascension.

Geodetic Survey of South Africa.—The field data of the triangulation connecting the northern end of the 30th meridian arc in the Transvaal with the existing triangulation in Rhodesia, executed by Captain Gordon, R.E., between October 1906 and January 1907, were received early in the year. The work has been completely reduced at the observatory, and the results forwarded to Sir D. Gill for publication.

The field work in Northern Rhodesia, after being carried as far as Mpange, S. lat. $9^{\circ} 41'$, or about 73 miles south of Lake Tanganyika, was abandoned in December 1906, and all field books containing the geodetic data were forwarded to the observatory for reduction purposes. The horizontal and vertical angles throughout the chain have been reduced and adjusted so far as is possible until a definitive length of the base measured in the Loangwa valley is arrived at.

The measurements of this base, as contained in the field books, have been completely reduced and discussed, and the length of the base has been derived in relation to that of the Russian standard bar used in the measurements; this bar has been forwarded to the "Bureau International" for standardisation, and the derivation of the actual length of the base is deferred until the results of this comparison are available.

The reduction of the astronomical observations, comprising latitude observations at 18 stations and astronomical azimuths at 2 stations, is well in hand, the field book data having been completely reduced and all star corrections computed. The discussion of the places of the 581 stars involved is now proceeding, but its completion awaits the re-observation of several of the stars with

the transit-circle, which will be secured during the early months of the current year.

Royal Observatory, Edinburgh.

(Director, Prof. F. W. Dyson, Astronomer Royal for Scotland.)

The recording micrometer referred to in last year's report as having been applied to the transit-circle has worked very satisfactorily, and the screw shows no appreciable wear. The observation of zodiacal stars has been pushed on vigorously, more than 4000 observations being made in the year. It has been found necessary to leave out of the observing list a number of stars of low declination which cross the meridian before midnight in the short summer evenings. With these omissions only about 200 more observations are required. As regards the computations, the observations as far as September 30 are reduced to mean place, and to apparent place as far as October 31.

Spectroscopic observations of the rotation of the Sun have been continued on the same lines as in previous years. From July the observations have been made photographically instead of visually. Sanction has been given for the purchase of a larger objective, and a 9-inch object-glass of 36 feet focal length is being constructed.

Forty photographs of nebulae have been taken with the 24-inch reflector. Difficulties have been experienced with this instrument owing to the shifting of the mirror, which have not as yet been quite overcome.

Seismographic observations have been carried on continuously, and the results communicated to the Committee of the British Association.

Meteorological observations have been regularly made. Two platinum resistance thermometers have been obtained and placed, one horizontally, the other vertically, in the rock at a depth of 3 ft. 9 in. The cracks in the rock allow of percolation of water, and experiments with two thermometers at the same depth was advised by Professor Callendar before proceeding to place thermometers at varying depths. Observations have been made daily since November 15.

Arrangements have been made to assist the Perth (Western Australia) Observatory in the measurement of the Astrographic plates. A micrometer has been obtained, and 100 plates have been received from Mr. Cooke.

The observatory has lost the services of Dr. Halm, who was appointed Chief Assistant at the Cape Observatory, and left Edinburgh in May. Mr. Clark was promoted to succeed him. The assistants' posts at the observatory have been placed on a more satisfactory footing, having been made permanent Civil Service appointments, a position formerly only occupied by Mr. Heath, the First Assistant.

Cambridge Observatory. (Director, Sir R. S. Ball.)

1. *Meridian Circle*.—The Syndics of the University Press have undertaken the printing of the large volume of meridian circle results 1872–1900 mentioned in the last report, and the work is making good progress. At the end of the year printing was completed up to R.A. $2^{\text{h}} 30^{\text{m}}$.

Advance copies of the results of the re-observation and examination of all the single observation stars of the Cambridge A.G. Zone Catalogue (to which reference was made last year) have been communicated to Dr. Ristenpart for incorporation in the *Geschichte des Fixsternhimmels*. All points of interest which arose have been thoroughly examined, and it is believed that very few discordances remain outstanding.

Observation of Gill's Zodiacal Stars has made good progress during the year, 1532 stars having been observed on 50 nights, with the necessary observations of fundamental stars and instrumental errors. The reductions to apparent place have been much interrupted by the work mentioned above, but are complete in R.A. to 1907 March 19, and in Decl. to 1907 September 10; and the reductions to mean place are complete to 1907 February 7.

Mr. Hartley has been in charge of the meridian circle, and has carried out the greater part of all the above work during the year.

The meridian circle clock, by Hardy, which has been in continual use since 1828, was thoroughly overhauled in 1907 January; with the exception of slight wear on one of the spring pallets, which should not affect the time-keeping, the clock is in perfect condition.

2. *Sheepshanks Equatorial*.—Two hundred and thirty-eight plates, each containing four or more exposures, have been taken by Mr. Hinks during the year, in continuation of the series for the determination of stellar parallax begun in 1904. On December 31 sixty fields were on the working list as partly observed, and thirteen had just been removed as completely observed at four or more epochs.

Sixty plates taken at Cambridge, which had been lent to Mr. H. N. Russell, of Princeton, U.S.A., were returned in 1907 April. Further consignments were sent to him of 28 plates in 1907 April and 13 plates in 1907 October, completing the series unfinished on his leaving Cambridge which he has undertaken to measure and reduce.

The new form of colour screen for bright stars has been in use since early in the year and appears to be quite satisfactory.

In preparation for the transit of Mercury on 1907 November 14, temporary alterations were made in the rectangular slides of the breech-piece, so that it became possible to take a series of 64 photographs of a segment of the Sun's limb at intervals of 3 or 4 seconds upon one plate. The sky was completely overcast on the day of the transit.

Mr. Stratton has finished his investigation of proper motions of faint stars in the Pleiades from plates taken at Greenwich, Oxford, and Cambridge; the results were contributed to the Society in 1908 January.

Mr. H. Knox Shaw (Trinity College: Sheepshanks Exhibitioner 1907) became a student at the observatory in 1907 October, and has begun work with the Sheepshanks telescope.

A new measuring machine, to take plates up to 10×8 inches, constructed by the Cambridge Scientific Instrument Company, has been brought into use during the year. It is a simplified form of the original Cambridge machine constructed by the same company in 1900, which has given complete satisfaction during its seven years of use.

3. *Reduction of Eros photographs.*—The first part (to 1900 December 31) of the photographic standard system of comparison stars is now complete, and is discussed in *Solar Parallax Papers*, No. 6 (in *M.N.*, 1907 December.) The second part is approaching completion. The system responds well to the tests which have been made upon it, and seems to be well adapted for use in the definitive reduction of the parallax plates.

Definitive places of most of the Crossley reflector comparison stars have been furnished to Professor Perrine. For a certain number the published photographic material was unsatisfactory, and many of these stars were too faint to be measured on Cambridge plates. The Astronomer Royal kindly undertook to measure these stars at Greenwich; he has already communicated the places of a first list of 48 stars, and a second list is under observation at the close of the year. The places of 33 very faint comparison stars used in micrometer observations of the planet have been measured on the Crossley reflector meridian series, and communicated by Professor Perrine.

Systematic corrections have been derived for most of the published series of photographic places of the planet, to reduce them to the new standard system. Printed forms have been prepared for the formation of the equations of condition in the final general solution, and a good deal of the preparatory formation of coefficients is done. A preliminary collection of the micrometric observations has also been made in order to see how far these may be used to strengthen the weak places in the photographic series.

The completion of the standard system of comparison stars made it possible to resume the measurement of the Cambridge photographs of the planet. Thirty-two plates, containing in all 281 images of the planet, have been measured during the year; the number of comparison stars measured on each exposure was about nine. The reduction of these measures is nearly complete. A number of star places required for the completion of the standard system were also derived from these plates.

Mr. Hinks has been aided in this work throughout the year by Miss Julia Bell; and Mr. S. E. Bowd has been engaged on the card catalogue and miscellaneous computing. The expense of this

assistance has been defrayed by a grant from the Government Grant Fund of the Royal Society.

4. *Floating Zenith Telescope*.—As noted in last year's report, Mr. Cookson has found it necessary to extend the observations with his zenith telescope over two years: enough material has now been gathered, the last photograph having been taken in July. The number of photographs available for determining the constant of aberration is 120. All of these plates have been measured in one position of the plate in the micrometer: about half have also been measured in the reversed position. The rest are now being measured. The reduction of all the measurements is in hand and is being carried out with the assistance of Mr. A. D. Campbell.

5. *Reduction of Lunar Observations*.—Mr. Stratton has continued his new reduction of Schlüter's observations of the Moon for comparison with Hayn's determination of the constants of the Moon's libration and of the selenographical co-ordinates of Mösting A, and the work is making steady progress.

6. Courses of instruction in practical astronomy, and in field astronomy and trigonometrical survey, have been given by Mr. Hinks during the year.

The Newall Telescope, Cambridge Observatory.
(Mr. H. F. Newall.)

The 25-inch equatorial was used in the early part of the year 1907, with the four-prism spectrograph, in photographing the red end of the spectra of the brighter stars. Special attention was paid to the spectrum of α Orionis in its relation to the spectrum of sun-spots. A note on some of the results was communicated to the Society in May (*M.N.*, lxxvii. 482).

Experiments have been made and are being continued in photographing star spectra with a diffraction grating, in order to decide whether the lines of the telluric B group can be satisfactorily utilised for determinations of stellar velocities.

Measurement and reduction of stellar spectra was carried on chiefly in the earlier part of the year.

The solar work has been carried on with the Littrow spectroscope and with temporary arrangements of cœlostat and image lenses. Meanwhile the permanent mounting for the cœlostat has been constructed, and was delivered at the observatory in December. It is expected that the new image lens of long focus which is to be used for the solar observations will be completed in time for the work in the spring or early summer.

The Littrow spectroscope has been used for the study of the cyanogen absorption-bands at wave-length 3883 in the solar spectrum. A note on some of the results was communicated to the Society in November (*M.N.*, lxxviii. 2). The instrument has been found very convenient to handle.

The same instrument has been used by Mr. Hubrecht in

preliminary work on the determination of the rotation of the Sun by the spectroscopic method.

A good deal of work has been devoted to the study of the spectrum of the electric arc under varied conditions in the laboratory.

Dunsink Observatory.

(*Director, Prof. E. T. Whittaker, Royal Astronomer of Ireland.*)

The staff consists, as at the close of the previous year, of the Director and Mr. C. Martin, assistant; the instruments in regular use are the Pistor and Martins meridian circle and the Roberts photographic reflector.

The reduction of the meridian observations of the red stars in the working-list prepared by the late Director, Professor Joly, has been completed during the year. A new working-list for the meridian circle has been prepared, forming an extension of the previous list, and consisting of stars of a similar character and variable stars; observations of these stars are now in progress.

The time service to Dublin has been continued as in previous years.

In the course of the meridian observations it was suspected that some of the red stars which have not hitherto been recognised as variables are such. Accordingly, the Roberts photographic reflector is now being employed in a determination of the photographic magnitudes of the red stars which are not known to be variables, with a view to the detection of variability.

The observatory library has been catalogued during the year.

The professorial courses of lectures delivered in Dublin by the Director have been entitled "Theory of Energy and Radiation" and "Theoretical Spectroscopy." Demonstrations in practical astronomy are given at the observatory by the Assistant Astronomer, and the south equatorial has been employed on the first Saturday in each month in showing objects of interest to visitors. The observatory was visited in July by His Excellency the Lord Lieutenant of Ireland.

Durham Observatory. (Director, Professor R. A. Sampson.)

The greater part of the year has been given to the theory and tables of Jupiter's satellites. A new theory has been developed, based upon the constants derived from the Harvard eclipses; it is hoped that this theory will prove of interest for its own sake; it has been much advanced in all its details during the year. The plan for the tables has been laid down, and some parts of them have been computed.

Observations with the Almucantar have been continued as heretofore: 602 stars were observed upon 40 nights.

Glasgow Observatory. (Director, Professor L. Becker.)

Good progress has been made with the reductions of observations obtained in former years. The observing work has been continued with transit-circle and spectrograph, but though all favourable occasions were utilised, the output is small owing to the few clear nights. The University authorities have under consideration a scheme which proposes to erect an observing station at some distance from this large manufacturing district.

The time service and the meteorological observations have been carried on as in former years.

Liverpool Observatory. (Director, Mr. W. E. Plummer.)

During the past year there has been little change in the instrumental equipment, the staff, or the work of the observatory. The meridian instruments and chronograph are kept at work regularly in order to ensure the distribution of correct time to the port of Liverpool. The apparatus for signalling has worked without failure throughout the year. As in past years, the equatorial has been devoted to the observation of comets, measures being made as long as the comet is bright enough to be seen. Measures of the position of the components of a few binary systems are made with regularity. These observations are confined to those stars that have long been observed, and for which the aperture of the telescope is suitable. In some cases the measures have been used to determine the orbits of binaries, employing as far as possible only those measures that have been made with instruments of similar size. It was hoped that more accordant results might be obtained if the influence of aperture were eliminated, but the accidental errors apparently mask any systematic discrepancies which might arise from this cause.

Some slight additions have been made to the instruments in the meteorological department, and the observations for climatology, etc. are continued as heretofore. The record of unfelt earthquakes with the Milne seismograph is regularly maintained. The results are freely communicated to all who are interested in these inquiries. The testing and rating of chronometers and the examination of other apparatus form part of the routine work of the observatory. Lectures in connection with the University of Liverpool are regularly given.

Radcliffe Observatory, Oxford.

(Director, Dr. A. A. Rambaut, Radcliffe Observer.)

During 1907 the work of this observatory has been continued on the same lines as in recent years, but its effective strength has been reduced by death and other causes. On January 21 Mr. E. E. McClellan, who had held the post of third assistant since 1892, died rather suddenly. Mr. H. Barrett, late computer at the Royal

Observatory, Greenwich, was appointed to succeed him on June 1. Towards the end of January, Mr. Reuben Harris, who had been employed as computer at the observatory since March 1903, resigned.

The investigation of stellar parallax has been carried on as vigorously as the weather would permit, but although no opportunity has been lost of photographing Professor Kapteyn's selected regions—the particulars of which were published in last year's report—cloud and fog in the early mornings have much interfered with the completion of this work. There still remain five plates of the region around Nova Persei, five plates of B.D. $+15^{\circ}$, 651 (Hyades), and two plates of B.D. $+31^{\circ}$, 1684, which require for their completion a third season's exposure. It is hoped that these exposures may be successfully carried out by the time this report appears. Five plates of the region surrounding Lalande 5761 have been sent to Professor Kapteyn at Groningen, and there measured and reduced under his direction, with satisfactory results.

Photographs of Daniel's Comet 1907 *d* were obtained on August 18, 20, and 26; and in preparation for the transit of Mercury on November 13–14 the 24-inch telescope was fitted with a short exposure shutter, and photographs of the Sun were taken in the principal focus. Clouds prevented any photograph being taken during the transit.

The 18-inch visual refractor was employed in examining the visibility of Saturn's rings on September 24, November 6, 26, 28, December 5, 6 and 14.

In the autumn of 1906 the heliometer, which has long been out of use, was dismounted, and the 10-inch Barclay equatorial erected in its place in February 1907. To this instrument has been adapted the Grubb bifilar micrometer made for the 18-inch. This combination proves very convenient for observations of double stars and comets. Micrometer measures of the position of Daniel's Comet have been made with it on July 30, August 11, 13, 18, 20, 26, September 8 and 11. Other miscellaneous observations made with this instrument include—

(1) Observations of Mellish's Comet 1907 *e*, on October 18, with the ring-micrometer.

(2) Comparisons of the magnitude and colour of Mira Ceti and α Ceti.

(3) Spectroscopic observations of solar prominences, especially of the great outburst of November 15, an account of which was published in *Nature*, No. 1986, vol. lxxvii.

(4) Transit of Mercury, seen for a few moments through clouds.

(5) Examination of Saturn and its rings on October 4 and November 23.

Naked-eye observations of Mira Ceti and comparison stars were made on January 2, 3, 6, 11, 17, 18, 22, 23, 29, 31, February 2, 10, 13, and 16. The results of the whole series of observations, continued from last year, were communicated to the Society, and published in the *Monthly Notices*, April 1907.

The computing strength of the establishment has this year been mainly directed to the reduction of the meteorological observations, but work in this department has been much interrupted.

A considerable amount of time towards the end of the year has been devoted to the examination of the original records and reductions of the observations made with the transit-circle under the direction of Main, 1862-76, with a view to elucidating a long list of discordances found by Herr Osten between the places published in the annual volumes and those of the *A.G. Catalogue*. This work was undertaken, at Dr. Ristenpart's request, for the *Geschichte des Fixsternhimmels*. The result of the examination has been to account for most of the discordances by errors in reduction, proper motion, or other causes.

Meteorological and Earth temperature observations have been made regularly as heretofore. It is intended to discontinue the latter (which have been carried on without interruption since 1898 November 1) at the end of 1909.

University Observatory, Oxford.
(Director, Professor H. H. Turner.)

Volume ii. of the Oxford Astrographic Catalogue was issued early in the year. Volume iii. (160 plates, centres $+29^{\circ}$: 62713 star images) was passed for press on July 10, and a few copies have been distributed. Volume iv. (160 plates, centres $+28^{\circ}$: 65,808 star images) is completely printed except the Introduction, so that the rate of two volumes per year is being maintained, thanks to the steady and devoted work of Mr. Bellamy and Mr. Plummer, and to the important assistance rendered by the Government Grant Committee of the Royal Society.

During the concluding months of the year the Equatorial was dismounted for various repairs, rendered necessary by its long and continuous service. The alterations and cleaning have been carried out under the superintendence of Mr. A. B. Chatwood, B.Sc., A.M.I.C.E., who accepted a modest and temporary post at the Observatory while awaiting confirmation of his appointment as Astronomer to H.H. the Nizam of Hyderabad. Special thanks are due to Mr. Chatwood for the great energy with which he has worked during these few months, and the number of suggestions for improvements in the instrument, which will remove various discomforts experienced in the past. He has also done work of a similar kind in other departments of the observatory.

Mr. H. C. Plummer applied, with the sanction of the Director, for a one year's Fellowship of the Lick Observatory, commencing last September. He will thus have an opportunity of acquiring familiarity with spectroscopic work, which has not yet been organised at this observatory.

The Variable Star observations of Pogson and the Baxendells have been put into the hands of the Director with a view to

publication. Those of Pogson were prepared for press by Mr. C. L. Brook, and are being printed in the *R.A.S. Memoirs*, a subsidy of one-third of the cost having been generously promised by Mr. Brook himself, and another third by the Indian Government. The observations of the elder Baxendell require much more work than those of Pogson, owing to frequent changes of the comparison stars; but, with the help of ungrudging volunteer labour on the part of Miss M. A. Blagg, of Cheadle, Staffordshire, considerable progress has been made with the arrangement in ledger form. Here also the Government Grant Committee have aided the work by a small grant for the more mechanical copying.

The Director attended the meeting of the International Union for Solar Research at Mendon, May 21-25. He has been asked to undertake the formation of a Computing Bureau, and, with a small subsidy from a private source, a beginning has been made by an investigation of the position of the Sun's axis from sun-spot records, on which preliminary note was published in the *Monthly Notices* for December last.

The Director also attended the meeting of the International Association of Academies at Vienna, May 28 to June 1, as a delegate of the Royal Society. He was nominated on the Committee appointed by the Association to consider the question of Lunar Nomenclature, and, at the request of the Chairman (the late M. Loewy), is acting as Secretary to the Committee.

Temple Observatory, Rugby. (Director, Mr. G. M. Seabroke.)

This observatory was used during the past year for teaching boys the use of instruments, and attempting to give them some taste for astronomy. The spare time has been taken up with measuring double stars.

*Solar Physics Observatory, South Kensington.
(Director, Sir Norman Lockyer, K.C.B.)*

Observations of Sun-spot Spectra.—The Sun was seen on 243 days during 1907, and observations of sun-spot spectra were made on 107 days, permitting the examination of 211 spots in the region F-D. The records continue to indicate that the lines affected are due to Vanadium, Titanium, Scandium, and Magnesium, in the presence of Hydrogen.

For the photographic record, with large dispersion, of the spectra of sun-spots a special instrument has been erected. It consists of a 12-inch siderostat, feeding a 12-inch concave mirror of 72 feet focal length, combined with a spectroscope, which is of Littrow form, using a 6-inch Cooke lens of 20 feet focal length, and, until a larger grating becomes available, a small plane Rowland grating with a ruled surface 1.9 × 1.3 inches (4.8 × 3.3 cms.), 14,438 lines to the

inch. The results already obtained are very promising, though its situation near the traffic of the adjoining street exposes the instrument to considerable disturbance.

Sun Photographs.—Daily photographs (glass negatives) of the Sun's disc are received from Dehra Dûn (India) and from Mauritius, the gaps in the Indian record being filled up as far as possible by negatives from Mauritius and Greenwich. The negatives are forwarded to Greenwich for measurement and reduction as they are required. Positives on paper are also received. These are mounted on cartridge paper and bound up into half-yearly volumes for ready reference. Since the beginning of 1906 enlargements of spectroheliograms for the same dates have been mounted alongside the paper prints for comparison.

Spectroheliograph.—The weather conditions were distinctly less satisfactory for the purposes of this instrument than during 1906, though fine enough on 142 days to warrant attempts being made to obtain monochromatic photographs of the Sun in "K" light. The instrument cannot be used very satisfactorily during the winter months on account of its position among high buildings. During the period January 3 to December 13, 1907, 351 negatives were secured; showing the distribution of "K" radiation on the Sun's disc. With the addition of an occulting disc over the primary slit plate 62 negatives were obtained, showing the prominences round the solar limb.

By arrangement with the Indian Government, photographs taken with the spectroheliograph at South Kensington and Kodaikānal are exchanged, so that the records may be as complete as possible for the year. During the period January 1, 1906, to September 30, 1907, 465 spectroheliograms have been received from Kodaikānal, while during the years 1906 and 1907, 111 positives, showing the Sun's limb in "K" light, have been forwarded to Kodaikānal.

The measurement of the spectroheliograms is now proceeding. Though, for many reasons, the work is extremely difficult, the consistency of the results, so far obtained, has been very satisfactory.

Stellar Spectra.—The weather conditions for night observations have been less favourable than during 1906. Fifty-two photographs of fifteen stellar spectra have been obtained with the 6-inch Henry prismatic camera with two prisms, and eight stellar spectra with the 9-inch prismatic reflector. The 2-inch quartz-calcite prismatic camera has been employed in photographing twenty pairs of stellar spectra, under conditions as nearly constant as possible, for recording extensions of the spectra in relation to the positions of the stars on the temperature curve of the Kensington classification. The weather has been extremely unfavourable for the photography of faint objects with the 36-inch reflector. Experimental work with plates specially sensitised for the green region showed a satisfactory advance. Among other photographs, a good spectrum, in the green region, of the Orion nebula was obtained.

Publications.—Papers dealing with the pressure data of 73 selected stations over the Earth's surface, the report of the eclipse expedition to Palma, Majorca, August 1905, the presence of sulphur in some of the hotter stars, the spectroscopic comparison of metals present in certain celestial and terrestrial light sources, observations of Sun and stars made in some British stone circles, prominence and coronal structure, and a note on the permanency of some photo-visual lenses, have been completed during the year, and others on allied subjects are in course of preparation.

Royal College of Science, South Kensington.
(Assistant Professor A. Fowler.)

Observations of the spectra of sun-spots have been continued in accordance with the scheme of the International Union for Solar Research. The spectra of the umbræ showed no perceptible differences as compared with those recorded in the preceding year, and dark D_3 was very frequently observed in the circumpenumbral regions. Solar prominences were also observed when time permitted, and particular attention was given to the bright lines visible in metallic eruptions.

Further investigations of terrestrial spectra have been made, with special reference to the interpretation of solar and stellar phenomena. A detailed account and table of wave-lengths of the titanium oxide flutings, which are characteristic of the Antarian (third type) stars, has been published (*Proc. Roy. Soc.*, vol. lxxix. A p. 509). An interesting result of the experimental work was the identification of the well-known sun-spot bands between E and F, with the component lines of the flutings of "magnesium hydride," a preliminary account of which was communicated to the Society in June. The continued investigation of this spectrum has shown that many other spot-bands in the yellow, green, and blue are also accounted for by magnesium hydride.

Stonyhurst College Observatory.
(Director, Rev. W. Sidgreaves, S.J.)

The solar surface has been observed as usual on all available days; 198 drawings of spots and faculæ have been made, and the greater spots have been examined with the grating spectrometer and the 12-prism spectroscope.

The new heliostat, mentioned in our last report, and also a 6-inch portrait lens—the gift of Mr. Whitelow, F.R.A.S.—have been mounted, but regular work with both instruments has been delayed by impediments experienced in the running of the driving-clocks. Sir Howard Grubb is surmounting those of the heliostat; and the Director, with the friendly help of Mr. Parkinson, a mechanician of Blackburn, has so far improved the equatorial clock gear and the

adjustments of the Whitelaw camera that probably no further difficulty will be experienced in a long and repeated exposure of the same photographic plate.

These and other mechanical improvements have occupied a considerable part of the year, and many of the clear nights have been devoted to experimental work in connection with them.

Work with the stellar spectrographs has been practically discontinued, pending an examination of the collection of plates already made. But this examination has been rendered impossible during the past year by the very long and laborious work, now complete, of re-casting all the meteorological computations of the last sixty years.

Some trials of Wratten and Wainwright's pan-chromatic plates on the brightest stars have been made with the Hilger compound prism. These carry the spectrum to Fraunhofer's C, and with them it is intended to complete the photographic records of the stronger spectra in our collection.

Wolsingham Observatory (Rev. T. E. Espin's).

Micrometrical measures of new pairs and neglected double stars have been continued throughout the year, and the results presented to the Society.

Mr. Franklin-Adams' Astrographic Laboratory.

In order to push on with the "Chart of the Heavens," all other work has been suspended and a second assistant engaged. Extra help has also occasionally been employed.

At the turn of the year a week-end conference upon several matters in abeyance was held at Mervel Hill with Sir David Gill, Professor Kapteyn, and Mr. Eddington, in order to make the work as useful as possible in the investigations now being carried on by them.

Messrs. Troughton & Simms have delivered the enumerating machine, and experimental investigations of numbers and magnitudes of stars upon the 15-inch plates are in hand.

Preparations for publication are in hand, but the scarcity of nights with three hours' spells of brightness makes it impossible to foretell the date of commencement.

A new workshop has been built for the production of 15-inch positives.

Sir William Huggins' Observatory, Upper Tulse Hill.

Photography of spectra, and experimental work in several directions, are being carried on in the observatory and in the laboratory.

Sir Wilfred Peek's Observatory, Rousdon, Lyme Regis, Devon.
(*Mr. C. Grover, Observer in charge.*)

The observatory and instruments are in good working order. The very changeable and unsettled weather of 1907 has been a great hindrance to observations, which were only made on 136 nights; this is less than usual. August, September, and October were the three best months, with 47 fine nights. The observations of long-period Variable Stars have been continued with the 6.4-inch Merz equatorial refractor, and 368 magnitude determinations have been made. Argelander's method has been followed, as in the previous twenty-two years this work has been in progress, during which a total of 10,075 magnitude determinations have been recorded.

Transits of stars are taken as often as required for regulation of the sidereal clock, which maintains a good steady rate.

The planet Mars was observed on 15 nights, and 13 drawings of the disc were made between July 1 and August 9; the presentation of the disc was much the same as in 1892, when a fine series of drawings were made by Professor Keeler, which appear in vol. li. of the *Memoirs R.A.S.* Many of these well-known features were well seen at the recent opposition.

Comet Daniel (*d* 1907) was observed on many nights between July 2 and August 21, at which latter date the comet was a fine naked-eye object with a tail 14° in length—the brightest comet which has been seen for several years. The disappearance of Saturn's ring was well seen. It was visible as a fine hair-line of light on either side of the planet on October 2, and the next night it had totally disappeared, no trace of it being seen with powers 80 to 310. On October 12 the air was so clear that six of the satellites were visible, but no trace of the ring.

Mr. Saunder's Observatory, Crowthorne, Berks.

The principal work has been in continuation of the measurement and reduction of the two Yerkes negatives of the Moon. The reductions of the plate dated 1901 November are completed, and the resulting places of 1800 points copied on to the card index. On that dated 1901 August about 800 points have now been completely measured and reduced; some 700 more are at present measured once only.

Dr. W. E. Wilson's Observatory, Daramona, Co. Westmeath.

During the last year practically nothing has been done with the 2-feet reflector. The weather still remains remarkably cloudy. Numerous experiments have been made with the radio-integrator, and that instrument now gives excellent results.

Kodaikánal and Madras Observatories.
(Acting Director, Mr. J. Evershed.)

The first five months of the year were, as is usual at Kodaikánal, extremely favourable for solar observations. September and December were also favourable, but the remaining five months were unfavourable.

Photoheliograms were taken on 339 days, and it was found possible to send to Greenwich all the negatives required to fill in the gaps in the Greenwich and Dehra Dûn sets of daily photographs.

Spots were observed on 352 days, and their positions approximately determined by projection. A total of 301 new groups was recorded, and the mean daily number of groups visible varied from 2·7 in June to 7·1 in February, the average for the year being 4·6.

Spectroscopic work.—Prominences were observed and their positions charted on 305 days. Detailed observations were also made of the bright lines in metallic prominences. Spot spectra were observed on 129 days, and a photographic investigation of the spectra of some of the larger spots of the year was successfully carried out, using a parabolic and a plane grating. Photographs were also obtained of the spectrum of Comet Daniel with a prismatic camera.

Spectroheliograph.—After the completion of the new sliding roof covering the siderostat, work was started on February 1. In April a new primary slit was fitted, and the design of the secondary slit was considerably modified. It was also fitted with a device for automatically recording the setting after each exposure. The instrument has since worked quite satisfactorily, and in the eleven months from February 1 photographs of flocculi were taken on 300 days and of prominences on 253 days. Altogether, 1840 photographs were taken.

Publications.—Bulletins Nos. viii. to xi. were published during the year.

At Madras, astronomical observations were confined to those necessary for the time service.

Perth Observatory, Western Australia.
(Director, Mr. W. Ernest Cooke.)

This year has been a memorable one for all the Australian State observatories, because it marks the definite separation of the two departments of Astronomy and Meteorology. Hitherto each observatory has had complete charge of the meteorological work of its State, but a Central Commonwealth Weather Bureau has now been established, and from 1908 January 1 each State Astronomer will be able to devote the whole of his time to Astronomy.

At the Perth Observatory the year 1907 has been marked by considerable progress. All the Catalogue plates have now been

taken, and measurement has at last been commenced. In June two lady assistants were appointed for this purpose, and during the latter half of the year they have measured 62 plates, containing altogether 25,157 stars, each one having been measured in duplicate.

In addition, Professor Dyson, Astronomer Royal for Scotland, has very kindly offered to assist in the measurement of the Perth plates. Arrangements have accordingly been made to send him a regular supply of plates and reference star positions from the most southern portion of our region (40°), whilst in Perth a start has already been made from the other end (32°).

It has been decided to measure only one image of each star, to duplicate each measurement with plate reversed, to disallow and repeat all measurements which differ in the two positions by 0.005 ($1''.5$) and upwards, and to publish results to three figures only. In justice to Professor Dyson, it should be stated that he wished to take the mean of the two images as was done at Greenwich, and the Director accepts the responsibility of limiting the measurements to the first image only (6 minutes' exposure). He was guided in this decision by Professor Turner's remarks in the Introduction to the Oxford Astrographic Catalogue, vol. i., top of page 25, also page 34, where it is shown that the effect of taking four instead of two measures is to reduce the total probable error of place from $\pm 0''.39$ to $\pm 0''.38$; and under the present circumstances the extra labour does not appear to be justified.

In the determination of the positions of the reference stars practically a new epoch has been inaugurated this year. The observation of the 422 standard stars was completed in March, and a Catalogue giving their positions for 1905.0 was printed and distributed a few months later. This is the first published Catalogue of the Perth Observatory, and it forms the basis of all subsequent work, in the manner therein described. At the end of March reobservation of the reference stars in zone $33^{\circ}-4^{\circ}$, which had been interrupted for a little over a year by the work of the Standard Catalogue, was renewed upon the fresh basis; that is to say, that instead of determining clock error from Nautical Almanac stars, and N.P.D. from nadir point readings, both clock error and equator point are now determined from the catalogued positions of at least six of the standard stars situated within the zone of observation.

The winter was, unfortunately, a phenomenally bad one, by far the cloudiest and most continuously wet that has ever been experienced here. But notwithstanding this, the transit observers made excellent progress, and succeeded in completing the zone $33^{\circ}-4^{\circ}$ on 1908 January 2; and, had there not been an exceptional rush of meteorological work in December, the reductions also would be up to date; as it is, they are only about a fortnight behind.

It has been considered advisable to apply corrections to the transit results obtained in previous years (zones $31^{\circ}-2^{\circ}$, $39^{\circ}-40^{\circ}$, and the first part of $33^{\circ}-4^{\circ}$) in order to reduce them to the present

Melbourne Observatory. (Director, Mr. P. Baracchi.)

The astronomical work done at this observatory during the year 1907 was as follows:—

Meridian Observations:—

	Observations in R.A.	Observations in N.P.D.
Clock stars	585	—
Azimuth stars.	315	59
List stars	1334	1331
Total	2234	1390

The list stars were selected from the Melbourne plates of the Astrophotographic Catalogue, to serve as fundamental points of reference for the reduction of these plates. The total number of this class of stars now completely observed not less than three times is 5965.

The Annual Catalogue for 1905 has been completed, and the Annual Catalogue for 1906 is nearly ready. The General Catalogue for 1900, including all stars observed since 1894, has been further advanced.

Astrophotographic Operations.—The Director regrets to report that the Assistant Observer, Mr. W. J. Wallace, who was connected with this work, died on 28th December last, after a long period of ill-health, which extended over the greater part of the year.

The following table shows the number of plates exposed during the year:—

	Passed as satisfactory.
Chart plates with triple exposure of 30 ^m each	13
Catalogue plates (duplicate series)	19
Test plates on South Polar regions	4
Plates for trails, adjustment of centre, etc.	9

The state of the Astrographic work allotted to this observatory is as follows:—

The first series of 1149 plates, covering twice the entire region south of Dec. -64° , and the series of chart plates with single exposure of one hour, whose centres lie on the parallels of even degrees of declination from 66° to the South Pole, were completed some years ago. A duplicate Catalogue Series is in course, of which 354 regions have been photographed.

In the series of chart plates with three exposures of 30^m each, having their centres on the parallels of odd degrees of declination, 532 plates have been taken. Thus, the original programme, so far as actual photographic operations are concerned, has been practically carried out.

It is intended, however, to complete the second Catalogue Series, and to extend the triple exposure chart plates to the regions of even degrees of declination, as the chart plates with single exposure of one hour are not considered satisfactory.

The measurement of plates will be dealt with in a separate report.

The following routine duties and other miscellaneous work were carried out for local public requirements as in former years:—

The Time Service, including daily time signals, control of public clocks, and rating of chronometers for the shipping.

The testing of nautical, meteorological, and surveying instruments.

The technical operations of the Bureau on Standard Weights and Measures according to law.

The Weather Service, including the control of some 1000 reporting country stations.

The continuous registration of the variations of sea-level, atmospheric elements, seismic disturbances, and the elements of terrestrial magnetism, including the reduction of magnetic records of past years.

An Australian Weather Bureau has been established by the Federal Government with headquarters in Melbourne, but not in any way connected with this observatory. The new institution assumed official control of the weather service of the various States of the Commonwealth on 1st January last, thus relieving the existing Australian observatories of all their public duties in connection with meteorology.

Joint Report of the Directors of the Melbourne and Sydney Observatories on the Measurement of the Plates of the Astrophotographic Catalogue.

The Catalogue plates of the Sydney and Melbourne Zones, covering the whole region south of -51° , are being measured at the Melbourne Observatory by a special Bureau established for this purpose towards the end of 1898, and maintained jointly by the Governments of New South Wales and Victoria.

The work of the Bureau during the year 1907 was carried on by a staff of six ladies, under similar conditions, and using chiefly the same pair of Repsold micrometric instruments as in former years.

The numbers of plates completely measured in the direct and reversed positions, in the course of the year, are—

138 Sydney plates, containing 97,881 stars.

56 Melbourne plates, containing 15,870 stars.

The total aggregate numbers of plates measured up to 31st December 1907 are as follows:—

700 Sydney plates, containing 423,859 stars.

892 Melbourne plates, containing 284,584 stars.

Sydney Observatory. (Director, Mr. H. A. Lenehan.)

In the early part of the year it was announced that the Government required the site of the observatory for other purposes, and intended to remove the instruments to a new position.

In May an Advisory Committee was appointed to act with the Government Astronomer, and many sites suitable for an observatory were inspected. The one finally selected was on or near the Canoblas mountain, in the vicinity of the town of Orange, 130 miles west from Sydney, where there is clearness of definition, freedom from city lights, electrical disturbances, and other troubles which are encountered in the present position of the observatory. Nothing has yet been decided as to the future, and the observatory is still fixed in the original site. The report of the Advisory Committee has not been acted upon.

The transit-circle piers and the graduated circles have been cased in, to shield them from air-currents which caused expansion and contraction. This was a very necessary work, and since it has been completed the instrumental corrections have been more constant. There has also been less tarnishing of the graduated silver bands.

Other instruments have been in the hands of the mechanician and placed in working order. A 6-inch Grubb equatorial telescope in the north dome required many alterations to make it effective. The alteration of the double pendulum escapement of the cylinder chronograph to a rotary one was much appreciated by the First Assistant. A new direction recording frame has been made for the anemometer. During the year 1908 a new sidereal clock is to be placed in the basement, where it will be free from air-currents and excessive changes of temperature. A 15-inch equatorial telescope is also to be ordered from Sir Howard Grubb.

New magnets have been received from Kew Observatory to use at the Red Hill branch, where the magnetic work is carried out. During December three members of the Astronomical Staff left to join the McClean and Lick Observatory parties for solar eclipse observations at Flint Island—two of them joining Mr. McClean. Should fine weather conditions prevail on the eventful day, they will obtain experience that should be of use to them when they are called upon to observe the solar eclipses in Tasmania in 1910 and in Australia in 1911.

Mr. Olden has qualified as an observer with the transit-circle, and is of much assistance during the absence of the members of the staff.

Improvements have been made in the buildings at the Red Hill branch. A large dark-room has been constructed for the developing of the Astrographic plates, and a new pier erected for the magnetometer.

The following observations have been made with the transit-circle:—

Number of R.A. observations of stars	1986
" N.P.D. " " " " " " " "	1665
" R.A. " " of Sun	447
The 9 A.M. Collimation, Nadir and Level readings .	306
9 P.M. Level readings	108
" Nadir determinations	108
" Azimuth determinations	118

The computations are in a forward state; the abstract for 1906 will shortly be completed, and a portion of the 1907 work is well in hand. The accumulated observations with the transit-circle for years back are being prepared for printing and publishing. Visitors were numerous, those in the daytime numbering 768, and during the evenings for lectures, etc. 534.

Two comets, *c* and *d* 1907, were observed in July and August, and photographs taken. This to a certain extent interfered with the Astrogaphic work, and the preparations for the departure of the party to observe the solar eclipse at Flint Island caused a further interruption towards the end of the year.

The readings of the magnetic declination at the Red Hill branch showed $9^{\circ} 28' 17''$ east, making for Sydney $9^{\circ} 32' 17''$ east—practically a constant determination. The intensity, vertical and horizontal forces have also been determined.

Tidal registrations on the coast and harbours of New South Wales have been continued.

The seismograph has been in use constantly during the year, and 80 earth tremors have been recorded on the photographic band. These have all been measured and tabulated, and the results forwarded to the Secretary of the Seismological Committee, London. The library has received about 750 books, pamphlets, etc., which shows a falling off in the number received during the previous year. This is probably accounted for by the separation of the two branches of the observatory. Meteorological books which were previously sent to this observatory may have been diverted to the Central Bureau, Meteorological Department, Melbourne.

Lovedale Observatory, South Africa.
(*Dr. Alex. W. Roberts.*)

The Director returned to South Africa in the end of March, and regular observations were carried on during the remaining nine months of the year.

The work done was, as heretofore, the observation of certain well-known southern variable stars.

Observations were made on 121 nights during April to December, and the following measures were secured :—

Algol variables (8 stars)	.	.	952 observations.
Short period variables (23 stars)	.	2052	„
Long period variables (69 stars)	.	2408	„
			5412
			„

During the past fifteen years the guiding aim of the work attempted at Lovedale has been to secure such a continuous series of observations of typical Algol and short period variable stars as might in the remote, or probably immediate, future give data for a determination of the orbital movements or physical conditions which produce or modify stellar variations of the eclipse and short period character.

It is hoped that this aim has to a certain extent been realised.

In the future the work done at Lovedale will be the examination of suspected variables, and of such long period stars as indicate secular variation in their light curves and periods.

During the year a determination was made of the value of the constant of atmospheric absorption.

Mr. Tebbutt's Observatory, Windsor, New South Wales.

Measures, several times repeated, of thirteen of the most interesting binary stars of the southern hemisphere constitute the only astronomical work at this observatory for 1907. The results will shortly be sent to the Society. Daily observations of two rain-gauges at different heights, and also observations of the various monthly maximum and minimum temperatures, have been secured during the year.

NOTES ON SOME POINTS CONNECTED WITH THE PROGRESS
OF ASTRONOMY DURING THE PAST YEAR.

Planets and Satellites.

The following 98 planets have been discovered or first announced during 1907. The year of discovery is 1907 unless otherwise noted.

Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer.
XJ 623	Jan. 22	L ₁	YU ...	Apr. 4	K	UN ^a	'06 July 16	W
XM 624	Feb. 10	K	YV ...	4	K	UN ^b	'06 July 16	W
XN 625	11	K	YW ...	5	K	ZT	... July 19	L ₁
XO 626	11	K	YX 632	5	K	ZU	... Aug. 8	K
XP ...	8	M	UM ^a	'06 June 20	L ₂	ZV	... 8	K
XQ ...	8	M	UM ^b	'06 June 20	L ₂	ZW	... 29	K
XR ...	4	L ₂	VE ^a	'06 Sept. 22	L ₂	ZX	... Sept. 8	W
XS 627	Mar. 4	K	VE ^b	'06 Sept. 22	L ₂	ZY	... 8	W
XT 628	7	K	WT ^a	'06 Dec. 6	L ₂	ZZ	... 8	K
XU 629	7	K	YY ...	Apr. 7	L ₂	AA	... 7	K
XV ...	7	K	YZ ...	7	L ₂	AB	... 11	K
XW 630	7	K	ZC ...	Mar. 20	M	AC	... 11	K
XX ...	6	M	ZD ...	Apr. 17	M	AD	... 11	K
XY ...	7	M	ZE ...	18	M	AE	... 11	K
YA ...	Feb. 15	M	ZF ...	11	M	AF	... 11	K
YB ...	Mar. 7	M	ZG ...	10	L ₂	AG	... 14	M
YC ...	7	M	ZH ...	15	L ₂	AH	... 18	S
YD ...	9	M	ZJ ...	May 9	K	AJ	... Oct. 4	K
YE ...	11	M	ZK ...	11	K	AK	... 4	K
YG ...	11	M	ZL ...	11	K	AL	... 4	K
YJ 631	21	K	ZM 633	12	K	AM	... 4	K
YM ...	Apr. 4	K	ZN 634	12	K	AN	... 4	K
YN ...	4	K	ZO ...	Apr. 5	L ₃	AO	... Nov. 1	K
YO ...	4	K	ZP ...	May 4	M	AP	... 3	K
YR ...	4	K	ZQ ...	5	M	AR	... 3	K
YS ...	4	K	ZR ...	11	M	AS	... 3	K
YT ...	4	K	ZS 635	June 9	L ₁	AT	... 3	K

Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer.
AU ...	Nov. 4	P	BA ...	Nov. 7	S	BG ...	Nov. 10	K
AV ...	4	K	BB ...	8	W	BH ...	30	K
AW ...	4	S	BC ...	8	W	BJ ...	Dec. 4	K
AX ...	5	S	BD ...	8	W	BK ...	Nov. 27	M
AY ...	6	K	BE ...	3	M	BL ...	Dec. 11	M
AZ ...	6	K	BF ...	4	M			

A planet found on Greenwich plates exposed 1903 August 6, 31, September 1, has been designated LX^a, UW is identical with 66, UZ with 408, WO with 260, WQ with 167, XK with 129, XL with 462, XZ with 469, YH with 236, YK with 411, YL with 629, YP with 62, YQ with 450, ZA with 510, ZB with 31, 615 with KR and KV, WK probably with 34, 635 with TU, UT probably with GX, YA with YF, AQ with 528, AX (probably) with 518, BA (probably) with 566.

The following planets, not numbered at the date of the last report, have since received permanent numbers: TE 602, TJ 603, TK 604, UU 605, VB 606, VC 607, VD 608, VF 609, VK 610, VL 611, VN 612, VP 613, VQ 614, VR 615, VT 616, VY 617, VZ 618, WC 619, WE 620, WJ 621, WP 622.

The following have received names: 398 *Admete*, 410 *Chloris*, 411 *Xanthe*, 414 *Liriope*, 426 *Hippo*, 427 *Galene*, 429 *Lotis*, 430 *Hybris*, 431 *Nephele*, 437 *Rhodia*, 438 *Zeuxo*, 441 *Bathilde*, 453 *Tea*, 497 *Iva* 506, *Marion*, 508 *Princetonia*, 517 *Edith*, 518 *Halawe*, 519 *Sylvania*, 523 *Ada*, 533 *Sara*, 534 *Nassovia*, 535 *Montague*, 537 *Pauly*, 583 *Clotilda*, 588 *Achilles*, 602 *Marianna*, 617 *Patroclus*, 620 *Drakonia*, 624 *Hector*.

The initials represent the following: K = Herr Kopff, Heidelberg; L₁ = Herr Lohnert, Heidelberg; L₂ = Prof. Lowell, Flagstaff, Ariz.; L₃ = M. Liapin, Pulkova; M = Dr. Metcalf, Taunton, Mass.; P = Dr. Palisa, Vienna; S = Herr Scheifele, Heidelberg; W = Dr. Wolf, Heidelberg.

VY = 617 *Patroclus* and XM = 624 *Hector* prove to have, like TG = 588 *Achilles*, orbits with nearly or quite the same period as Jupiter, exemplifying more or less closely Lagrange's proposition of the stable motion of three bodies at the vertices of an equilateral triangle. The longitude of VY *Patroclus* is less than that of Jupiter, that of the other two is greater. Both *Achilles* and *Patroclus* have been well observed at their second opposition, so materials are available for determining their orbits accurately. The question of the stability of these orbits, both as regards the Jupiter perturbations and those of the remaining planets, is an interesting one, and has not yet been completely solved.

Dr. Ross has published new elements of Jupiter's satellites VI. and VII. Those of the former are based on the early places

secured from Harvard plates of 1894, 1899, as well as those since the discovery.

Elements referred to Earth's equator 1905'0:—

	Satellite VI.	Satellite VII.
ϖ	268°82	114°22
Ω	171°00	291°45
i	5°55	25°31
l	20°00	238°23
e	0°155	0°207
Sid. period	250 ^d .618	260 ^d .06
a for log $\Delta = 0.71624$	3°37"	3°13"
	VI.	VII.
Annual increase of ϖ on Earth's equator,	1°493	°
Annual increase of ϖ on Jupiter's orbit,	1°373	1°44
Annual decrease of Ω on Earth's equator,	4°358	
Annual decrease of Ω on Jupiter's orbit,	1°207	1°35
Inclination of orbit to Jupiter's orbit .	28°747	27°972

Dr. Ross also gives the principal perturbations, of some of which the approximate values are given here (Delaunay's notation).

VI.	$dL =$	VII.	VI.	$d\frac{a}{r} =$	VII.	VI.	$d\beta =$	VII.
+ °3	$\sin (2D - 2l)$	+ °5	+ °007	$\cos (2D)$	+ °014	- °5	$\sin (F - l)$	- °6
+ °3	$(2D - 2F)$	+ °3	+ °003	$(2D + l)$	+ °006	+ °4	$(2D - F - l)$	+ °6
+ °2	$(2F - 2l)$	+ °3	+ °018	$(2D - l)$	+ °024	- °5	$(F - 2l)$	- °9
- °4	l^2	- °4	+ °002	$(2D - l - l^2)$	+ °003	- °6	$(3F - l)$	- °7
+ °5	$2D$	+ °8	- °007	$2F$	- °010	- °3	$3F$	- °4
+ 2°3	$(2D - l)$	+ 3°2	- °002	$(2F + l)$	- °004	+ °8	$(2D - F)$	+ °8
+ °3	$(2D - l - l^2)$	+ °4	- °024	$(2F - l)$	- °030	+ °5	$(2D + F - l)$	+ °7
- °5	$2F$	- °8				+ °3	$(2D + F)$	+ °4
- 2°7	$(2F - l)$	- 3°4						

A. C. D. C.

The Comets of 1907.

Five comets have been discovered during the year, and the order of discovery has followed that of perihelion passage.

Comet 1907 (a), discovered on March 9 at Nice by M. Giacobini, was carried rapidly towards the Sun, and observations soon ceased. But late in the year the comet, though faint, was again in a favourable position for observation, and was photographed by Dr. Max Wolf on December 4, who estimated the brilliancy as that of the 14th mag. The elements, which are not yet definitely known, resemble those of Comet 1890 IV. ; and though the identity

of the two objects is impossible, they may have had a common origin.

Comet 1907 (*b*) was first seen by Mr. Grigg, of Thames, New Zealand, on April 9, but intelligence of its discovery was first circulated by Mr. Mellish of the Washburn Observatory, who saw the comet on April 14. The trace of the comet was subsequently found on a plate taken on April 13 by Professor Barnard, while searching for Giacobini's comet. The object was faint and the observations were not numerous. The orbit is interesting, since the elements are similar to those of 1742, a bright comet first seen at the Cape of Good Hope, but also observed in Europe.

Comet 1907 (*c*), discovered on June 1 at Nice by M. Giacobini. This was also a faint comet and was observed for only a short time, but it is not impossible that it may be re-observed in the spring. There is no reason to think that the orbit differs from a parabola.

Comet 1907 (*d*), found by Mr. Daniel of the Princeton Observatory on June 9, was the brightest comet of the year, and in the morning sky of August was quite as conspicuous as a star of the second magnitude. Numerous observations and photographs were secured, the latter disclosing a tail of very complicated structure, extending at least 17° from the nucleus. There was also some evidence of a rotatory motion of the comet about a line joining the nucleus and Sun.

The perihelion passage took place on September 3, and after perihelion observations were possible, the comet being picked up on November 5 by Dr. Hartwig, who reported it as of the eighth magnitude.

Comet 1907 (*e*) was first observed by Mr. Mellish, of the Washburn Observatory, on October 13. For some weeks the comet increased in brilliancy, and was so favourably placed that it could be observed on the meridian. The brightness faded very quickly, however, after the middle of November, diminishing more rapidly than the ordinary accepted formula would explain.

It will be noticed that no periodical comet * has returned during the year, and no new elliptic comet of short period has been detected. Denning's Comet of 1881 V. unfortunately passed through perihelion without being perceived. A similar fate overtook the same comet in 1890 and 1899; and since the mean motion could not be determined with great accuracy in 1881, this object must be considered lost. Swift's Comet 1894 IV., an object of unusual interest on account of its supposed identity with the lost comet of De Vico, passed through its perihelion about the beginning of July, but was not seen. The chances of recovering this comet are very slender. Comet 1900 III. (Giacobini) also passed undetected.

On the other hand, as evidence of long continued visibility of

* Encke's Comet was photographed at Heidelberg by Dr. Max Wolf on December 25, but the cometary character was not recognised till January 3, 1908.

comets, attention may be drawn to the fact that observations of Comet 1905 IV. already extend over a period of more than three and a half years, and may be even further prolonged. Observations of Comet 1904 I. extend from 1903 May 14 to 1905 June 5, or 753 days.

Spectrum of Comet d 1907.—The position of this comet in the sky was not very favourable for spectrum observations, but MM. Deslandres and Bernard at Meudon, Dr. Rosenberg at Göttingen, and Mr. and Mrs. Evershed at Kodaikānal have obtained valuable results.

In addition to the details shown by the nucleus, which exhibit the ordinary characteristics, including the cyanogen band at λ 388, first seen by Huggins in the comet of 1881, the spectrum of the tail has been photographed for a distance of at least 45' from the head. The spectra of the head and tail do not rigorously coincide. While some bright bands are entirely confined to the nucleus, fainter bands can be traced to a considerable distance in the tail; and further, some faint bands in the nucleus, whose chemical origin is not yet clearly ascertained, are not reproduced in the tail.

It has therefore been suggested that the constitution of the nucleus and that of the tail of the comet are not similar. In connection with the same subject, attention should be called to a paper by Mr. H. F. Newall, in which he has described the alteration produced in the spectrum of cyanogen under various conditions of pressure. In this same paper Mr. Newall, after pointing out that gases and vapours must exist in circumsolar space, a fact that is sufficiently indicated by the extension of the corona and the length of comets' tails, offers an explanation of the presence of those features of the spectrum common to all comets. He submits that it is more probable that the approximate similarity in the spectra of all comets is due to the fact that these objects come in contact with the same vapours, spread in their path as they approach the Sun, and by some process elicit the spectra of these vapours, than that comets starting from all parts of the universe should bring with them the cyanogen and hydrocarbons shown in their spectra.

The orbits of the following comets have been definitely determined during the year :—

Comet.	Character of Orbit.	Calculator.	Place of Reference.
1796	Parabolic	H. A. Peck	<i>Ast. Journal</i> , No. 596
1819 II.	"	"	" " 593
1822	"	"	" " 596
1826 II.	"	Cowley and Whiteside	{ <i>Erganz. zu den</i> <i>Ast. Nach.</i> No. 13.
1905 V.	"	G. Zappa	{ <i>Annali dall' Obs.</i> <i>Coll. Romano</i> , vol. iv.
1906 I.	"	Terkan and Czuczy	<i>Ast. Nach.</i> No. 4218

The return of Halley's Comet in 1910 has attracted considerable attention. The discrepancy between the time of perihelion passage computed by Pontécoulant and the time indicated by Ångström's curve, founded on two supposed inequalities based on Hind's identification of ancient returns, suggested the necessity for further computations. Such a revision was the more necessary owing to the detection of a suspicious error in the value of the perihelion distance assigned by Pontécoulant.

Attention was first directed to this subject by Mr. Crommelin, but later Mr. Cowell has collaborated, with the result that the method of calculating the perturbations of long period comets has been examined and simplified, and the necessary formulæ have been put in a very practical form. The object of the inquiry has been twofold. First, to determine with the necessary accuracy the date of the comet's perihelion; secondly, to trace backwards the course of this famous comet, and to identify its several returns. With regard to the first part of the investigation, the result has been to confirm the general accuracy of Pontécoulant's prediction. He assigned 1910 May 23 as the date of next perihelion passage; and Messrs. Cowell and Crommelin show that the period he has assigned requires to be shortened by nine, and two days for the actions of Jupiter and Saturn respectively. Further, the large value for the perihelion distance given by Pontécoulant is clearly in error. The historical research, so far as it has been carried, proves that the comet returned in 1301, as suggested by Hind. The result is the more satisfactory, as very considerable doubt attached to that particular date owing to the misdescription of the comet's position by contemporary observers. The certainty of identification has been carried one revolution further back, and it is understood that more distant epochs will be investigated.

W. E. P.

Solar Activity in 1907.

Sun-spots.—There has been a distinct increase in the spot-activity of the Sun during 1907 as compared with the preceding year, though the level of 1905 was not quite attained. The number of giant groups readily visible to the naked eye has been double that recorded in 1906, and equal to that of 1905, no fewer than 24 distinct groups large enough to be thus seen having been observed during the year. The chief groups of this rank were on the disc 1906 December 29–1907 January 9, January 28–February 7, February 6–19, June 13–25, July 11–23, September 24–30, October 15–25, November 9–22, and December 5–18. The tendency, so marked in 1906, to develop long processions of groups following each other at short intervals along a parallel of latitude has continued in 1907, and on more than one occasion the Sun, as seen merely through a dark glass, presented a very fair imitation of a Martian "canal," in the shape of a long, straight narrow scar.

The first two months of the year were the most disturbed, and it is not improbable that the crest of the wave may eventually be found to lie somewhere within their limits, unless the revival, evident in 1907, should be still further accentuated in 1908. Faculae were most numerous in March, which was, so far, the most prolific month for these bright markings during the whole of the present maximum. Two days at the end of November showed the Sun free from spots.

E. W. M.

Prominences.—The daily frequency of prominences deduced from spectroheliograms taken on 40 days during the year 1907 was somewhat greater than that deduced for the preceding year, also from photographs secured at the Solar Physics Observatory, South Kensington. The pictures were taken with the "K" line (calcium) of the solar spectrum, and the lower limit for the height of prominences accepted was about 20". The photographs examined seemed to indicate that for the year 1907, unlike the previous year, the activity was fairly equally divided between the two hemispheres, the figures obtained for the last three years being as follows:—

	1905.	1906.	1907.
North hemisphere . . .	3'4	3'9	3'5
South hemisphere . . .	3'0	2'6	3'9
Total daily frequency	6'4	6'5	7'4

The above figures for the total daily frequency indicate a lag of the maximum prominence activity behind the maximum of spotted area which occurred late in 1905, though the spotted area of 1907 will probably show an increase over 1906.

Activity apparently in the neighbourhood of the solar poles was less marked than in 1906, while equatorial prominences were not infrequent.

From July 15th to the 20th the Sun appeared very active, showing many high and remarkable prominences; fortunately good weather allowed a number of excellent photographs to be obtained.

The visual observations of prominences made at Catania by A. Riccò* indicate for the first six months of 1907 a considerable increase over the mean frequency for 1906. The lower limit of height of observed prominences was 30".

	1906.	1907 (first semestre).
North hemisphere . . .	1'56	2'15
South hemisphere . . .	1'06	1'66
Total daily frequency	2'62	3'81

The distribution in latitude shows for the activity in 1907 maxima at 36°–40° and 51°–55° in the north solar hemisphere, and 15°–19° and 40°–44° in the south.

W. J. S. L.

* *Memorie della Società degli Spettroscopisti Italiani*, disp. 12, vol. xxxvi.

Solar Research.

The International Solar Union.—An important event in 1907 was the Third Conference of the International Union for Co-operation in Solar Research, which was held at Meudon in May, under the presidency of the late Dr. Janssen. Reports of the work of the committees on standard wave-lengths, sun-spot spectra, solar radiation, and spectroheliograph observations were presented, and new committees were appointed to deal with solar rotation problems, and the organisation of solar eclipse work.

The re-determination of the wave-length of the red line of cadmium has been completed by Messrs. Fabry and Perot, and is in such satisfactory agreement with the independent results obtained by Michelson and others that it was resolved to adopt it as the basis of the new wave-length tables. The work on the secondary standards was also reported as well advanced, and the wave-length committee was authorised to issue a definitive table without waiting for its formal adoption.

The next Conference will be held at Mount Wilson, California, in the autumn of 1910.

Sun-spot Spectra.—Investigations of the spectra of sun-spots have made great progress during the year. The visual observations which have been so laborious in the past have now been greatly simplified by the admirable photographic map of the spot spectrum which has been prepared at Mount Wilson, and, through the kindness of Professor Hale, distributed among the observers in this section of the work of the International Solar Union. Some very fine photographs have also been secured at Kodaikanal, and the photographic method is also being successfully employed by Mr. Newall at Cambridge, and by Father Cortie at Stonyhurst. The records of the phenomena are therefore now perfectly definite, and experimental work tending to their elucidation is enormously facilitated.

Hale and Adams have given an account of further investigations which they regard as supporting the view that the modifications of the metallic lines in spot spectra are to be explained by reduction of temperature, the flame lines being strengthened while the enhanced (spark) lines are weakened. Further evidence in the same direction is also afforded by their very satisfactory identification of the stronger flutings of titanium oxide in the spots, those having heads at 7054·60, 7087·90, and 7125·89 being very strongly marked (*Ap. J.*, xxv. 75-94). The spot spectrum thus shows an approximation to the third type stars, of which the titanium oxide flutings are characteristic. An interesting paper in this connection has been published by Father Cortie (*Ap. J.*, xxvi. 123), who points out that at the maximum of *Mira Ceti* in 1906 the flutings were much less developed than at the maximum of 1897, when the magnitude at maximum was lower. Assuming the greater

brightness to be associated with a higher temperature, the appearance of the flutings in sun-spots points to the conclusion that the temperature of sun-spots is lower than that of the photosphere.

Many of the numerous spot "band lines" in the region E to F have been identified by Fowler with components of the fluting of "magnesium hydride," the head of which is at 52110 (*M.N.*, lxvii. 530). It is probable that this will throw much light on the discontinuity of the dark background of the spot spectrum, which gives rise to the appearance of bright lines and bands. There is evidence that the absorption of this substance is also shown faintly in the normal solar spectrum.

The weakened lines in spots have received special attention from Mr. Nagaraja of Kodaikānal, who has catalogued 167 of this class between F and D. In accordance with the previous observations of Fowler, and Hale and Adams, it is found that enhanced metallic lines figure largely among the weakened lines, and that many of them occur as high-level lines in the chromosphere (*Ap. J.*, xxvi. 143).

A remarkable feature of the sun-spot spectrum is the tendency to disappearance of characteristic features in the violet and ultra-violet, the spectrum there gradually approximating to that of the ordinary disc. Hale and Adams have discussed this matter in the paper to which reference has been made above; and though they have reached no explanation which they consider final, it is suggested that the effect may be largely due to solar light diffused over the spot area. At Kodaikānal, "with improved apparatus and under exceptionally favourable atmospheric conditions," affected lines have been photographed in the region 3990 to 4350, but Mr. Evershed questions whether the admixture of skylight with the spot spectrum is a sufficient explanation of the poverty of detail. Titanium and vanadium account for many of the strengthened lines in this region as well as in the visible spectrum (*M.N.*, lxviii. 12).

Closely associated with the study of sun-spot spectra is the important investigation of the spectrum of the Sun's disc near the limb, which has been made at Mount Wilson (*Ap. J.*, xxv. 300). It is found that the "wings" of many lines disappear at the limb, and that the relative intensities of numerous lines are changed, generally in the same direction as in spots, though the weakening is relatively more marked than the strengthening of lines. The further discussion of these results, which is promised, will be awaited with great interest.

Useful notes on the conditions which accompany the appearance of bright D_3 over the umbrae, and of dark D_3 in the neighbourhood of spots, are given by Mr. Nagaraja and Capt. Daunt (*Observatory*, 214, 249).

The Sun's Rotation.—The spectrographic method of observing the Sun's rotation has been employed by Mr. Newall in order to determine whether the cyanogen band 3883 in the solar spectrum is wholly of solar origin (*M.N.*, lxviii. 2). In the observations made during August and September the band generally showed a double head at the east limb, as if there were two bands superposed, while

at the west limb there was only a slight intensification, without measurable duplication. It is suggested that some cyanogen having independent motion must have existed in interplanetary space between the Earth and Sun, and not far from the Sun, and the possible connection with the *debris* of comets is discussed.

The results of the first systematic investigation of the Sun's rotation by the spectrographic method have been announced by W. S. Adams (*Ap. J.*, xxvi. 203). Granted an apparatus as powerful as that used at Mount Wilson, the many advantages of the photographic method are obvious, particularly as regards the number of lines which may be utilised. In this investigation twenty lines of various origins were selected for measurement, and the general means give 24.46, 24.79, 25.48, 26.43, 27.63, 28.73, 29.63, 30.25, and 30.56 days as the rotation periods for heliographic latitudes 0, 10, 20, 30, 40, 50, 60, 70, and 80 degrees respectively. For the lower latitudes the values agree very closely with the results of Dunér and Halm, and for the higher latitudes are intermediate between the results of these observers. A fact of great interest is that different lines give slightly different rates of rotation, those of carbon and lanthanum showing 0.1 less than the daily rate indicated by the mean of all the lines, while two lines of manganese give systematically high results.

In connection with the Computing Bureau of the Solar Union, Professor Turner has made a preliminary investigation of the position of the Sun's axis, as deduced from the Greenwich sun-spot measures (*M.N.*, lxviii. 98). A small and possibly periodic departure from the axis deduced by Carrington is indicated.

The Spectroheliograph.—Records of the calcium flocculi are being regularly made at Mount Wilson, Kodaikanal and other observatories. In addition, Hale has made investigations in which lines affected in sun-spots have been adjusted to the position of the second slit. In the case of strengthened lines, the umbrae and penumbrae of spots are relatively darkened and the areas are considerably increased; and definite, though less marked, results have been obtained with enhanced lines. Successive pictures of the calcium flocculi have also been prepared for use in the stereoscope, showing the sphericity of the Sun and the apparent elevation of the flocculi. Features which escape notice in single photographs are brought into prominence by this method of observation (*Ap. J.*, xxv. 311).
A. F.

The Moon's Physical Libration.

Between 1898 and 1900 Dr. F. Hayn conducted with the 30 cm. refractor of the Leipzig Observatory a series of measures in order to determine accurately the selenographic co-ordinates of a number of points on the Moon's surface. He intended to reduce these on the supposition that the rotation elements of the Moon and the position of Mösting A, as given by Franz's reduction of Schlüter's observations, were substantially accurate. In the course

of his work he found reason to doubt the truth of this assumption, and accordingly he undertook a complete revision of the analysis on which the reduction is based. The aim he set before himself was to include every term in Hansen's theory which could produce an effect amounting to 2" in selenocentric or 0".1 in geocentric arc, and to carry through the reductions to this degree of accuracy.

Since the first series of observations were planned for a different purpose, and were not suitable for determining the position of Mösting A, or the coefficients of the principal terms in the Physical Libration, a fresh series was undertaken towards the end of 1903, in which the distance and position-angle of Mösting A were determined on ten evenings, sometimes from as many as eighteen points on the limb. The measures were made with a filar micrometer, and the distances were so great that considerable reliance had to be placed on the driving-clock, but the results seem to justify the confidence placed in its accuracy.

When the observations were reduced it was felt that they did not justify a definitive determination of the rotation elements, and it was decided to make a fresh reduction of the similar measures made by Hartwig between 1877 and 1879 with the Strassburg heliometer. This work has now been accomplished, and the final results are published under the title of "Selenographische Koordinaten" in Bd. xxx. der *Abhand. der Math. Phys. Klasse der k. Sächs. Gesell. der Wiss.*, the previous work having been published in Bdn. xxvii. and xxix. of the same series. The principal points in the reduction are that greater care is taken in the integration of the equations not to neglect terms which would affect the result to the degree stated, and that account is taken of the departure of the surface of the Moon from that of a sphere, the amount of this departure being determined from the observations themselves.

The principal results may be stated as follows:—

If A, B, C are the Moon's principal moments of inertia, A being that about the equatorial diameter through the zero meridian, C about the axis of rotation,

I the mean inclination of the Moon's equator to the ecliptic,

λ, β the selenographic longitude and latitude of Mösting A,

h the radius to this point,

$h_{N.A.}$ the radius assumed in the *Nautical Almanac*, = 15'34".21,

g the Moon's mean anomaly,

g' the Sun's mean anomaly,

ω the departure of the Moon's perigee from the ascending node of its orbit,

then Dr. Hayn finds—

$$f = \frac{C-B}{A} \frac{B}{C-A} = 0.75 \pm 0.04$$

$$I = 1^{\circ} 32' 6'' \pm 15''$$

$$h = h_{N.A.} + 0''.50 \pm 0.56$$

$$\lambda = -5^{\circ} 10' 13'' \pm 15''$$

$$\beta = -3^{\circ} 10' 58'' \pm 12'',$$

which correspond to the rectangular co-ordinates

$$\xi = -\cdot 08998, \quad \eta = -\cdot 05552,$$

whilst the physical librations are

$$\begin{aligned} &\text{in longitude } -12'' \sin g + 59'' \sin g' + 18'' \sin 2\omega \\ &\text{in latitude } -144'' \sin \omega + 11'' \sin (g + \omega). \end{aligned}$$

The coefficients of $\sin g$ and $\sin g'$ are about half those found by Dr. Franz, whilst the libration in latitude takes a different form. Dr. Franz's value of f was $0\cdot 49$.

The errors given are those of mean square.

Dr. Hayn also gives the co-ordinates of four points of the first order. Those of fifteen other points of the second order are promised in a fourth memoir.

The libration considered is that due to the forced oscillations whose periods are determined by the configuration of the system Sun, Earth, Moon. A search was made for evidence of free oscillations, but, like previous attempts, it showed only that the amplitudes must be very small.

The *Berliner Jahrbuch* for 1909 contains an ephemeris for Mösting A deduced from these elements.

But even those now published cannot be considered definitive: the magnitudes of some of the results depend upon an arbitrary system of weighting adopted for the conditional equations, and it is imperative that some of the other series of observations, of which there are several in existence, should be re-reduced. The work of reducing those made by Schlüter has already been commenced at Cambridge by Mr. Stratton.

Dr. Hayn also publishes a provisional table and contour map showing the difference from mean level at every point of the surface which can come upon the limb. In 1905 he published a table of the same kind in *Ast. Nach.* 4009; this he now withdraws in favour of the new table, depending on a more complete reduction of the same observations.

Dr. Hayn is to be congratulated on having brought to a successful termination a very laborious piece of work, in which he deals with quantities that are near the limit of what can be observed. He has considerably improved our knowledge of the rotation elements and the contour of the Moon, and has shown how a still further improvement may be effected.

S. A. S.

Action of the Planets on the Moon.

In 1892 M. Radau published his researches on the planetary inequalities in the movement of the Moon. The past year has been marked by the publication of investigations by Professor Newcomb*

* Investigations of Inequalities in the motion of the Moon produced by the action of the planets.

and Professor Brown* dealing with the same subject. A comparison of the three memoirs is given by the latter in the *Monthly Notices* of last January. The differences between any two of the three theories only occasionally rise to quantities that could be detected by a discussion of the observations. The two later memoirs agree in increasing M. Radau's† coefficient of the Jupiter evection term by a quarter of a second, and there are instances when Professor Newcomb differs by a tenth of a second from the other two. Many of these discrepancies are traced to their source by Professor Brown in the paper referred to above.

No new light is thrown on the observed long period inequalities of the Moon. A fresh discovery could only have been hoped for on the supposition that M. Radau had made an oversight of considerable magnitude, and perhaps the deepest impression made by the two recent memoirs is the sense of the excellence of M. Radau's original research.‡

P. H. C.

Double Stars.

The abbreviations used are—

M.N. : *Monthly Notices*.

A.J. : *Astronomical Journal*.

A.N. : *Astronomische Nachrichten*.

L.O.B. : *Lick Observatory Bulletin*.

A number of new double stars have been added during the year:—Thus in *M.N.*, 1907 May and 1908 January, the Rev. T. E. Espin gives 148 new pairs, of which 78 are under 5" separation and 70 over 5". These make 551 discovered by Espin. In *L.O.B.* No. 109 are 250 new doubles by Aitken, of which 54% are under 1" separation and 200 more in *L.O.B.* 125. Mr. Aitken's discoveries now number 1700. Mr. Hussey brings his discoveries up to 1337 by the new pairs in *L.O.B.* 127.

Measures of known pairs have been much the same as in previous years. The Greenwich measures made in 1906 are in *M.N.* 1907 November. They contain about 150 Hough stars and about 250 miscellaneous pairs. The measures of Southern doubles made with the 26-inch refractor of the McCormick Observatory are in *A.N.* 4166; and in Nos. 4180, 4193 are measures of 250 wide pairs made at the Urania Observatory, Copenhagen. Burnham's measures of 200 wide pairs with the 40-inch Yerkes refractor are in No. 4209. Less numerous sets will be found in

* The Inequalities in the motion of the Moon due to the direct action of the planets.

† Dr G. W. Hill obtained the same coefficient as M. Radau, but he has corrected his result in *A.J.* No. 600.

‡ Recherches concernant les Inégalités planétaires du mouvement de la Lune, *Paris Obs. Ann. (Mém.)*, vol. xxi

A.J. 591 of 55 pairs with the Kirkwood 12-inch; in *M.N.*, 1908 January, of 86 pairs by Rev. T. E. Espin; and of 44 pairs at the Morrison Observatory. The measures of 1100 pairs made at the Observatory of Chevreuse by M. Farman in the years 1904-1906 are worth special notice. The measures were made with a $9\frac{1}{2}$ -inch Cooke triplet.

The idea of M. Farman was to bring the Catalogues of Flammarion and Wilson-Gledhill up to date, and hence he supplements his measures by all those made of these particular stars since 1878, and it forms thus a fair-sized volume.

There have been two papers on the positions of the poles of Binary star orbits. One by Professor Turner and Mr. Lewis in *M.N.*, 1907 June, where 59 orbits are discussed and the evidence found to slightly favour the view that their poles lie near the Galaxy. The other paper is by Karl Bohlin (*Arkiv för Matematik, Astronomie och Fysik*, Stockholm, Band 3, No. 19), wherein, by making choice of the alternative poles, the opposite conclusion is deduced.

The orbits computed are— ξ Scorpii, Σ 2173, Σ 3121, μ^2 Herculis in *A.N.* 4169-70, and of α Centauri in No. 4189, all by Dr. Doberck, and of β 612 by Mr. L. Semenow in *Popular Astronomy*, 1907 December.

Herr Zeipal gives parallax of Σ 443 as $+''\cdot 057$ in *A.N.* 4188, and Chase, in *A.J.* 593, gives $+''\cdot 291$ for 61 Cygni.

The principal event of the year in double star astronomy is the publication of Burnham's *General Catalogue of Double Stars*. This title includes two large volumes: (i.) the Catalogue proper; (ii.) Notes on the Stars in volume i. The catalogue, consisting of 330 pages, contains 13,665 double stars, arranged in order of R.A. (epoch 1880), and with the usual data for a working catalogue. Volume ii., consisting of 830 closely printed pages, gives a few selected early measures of the great majority of the stars contained in volume i., and a number of recent measures of many pairs not published elsewhere, together with notes sufficient to enable anyone to make out a working catalogue suitable to his geographical position and equipment, as all stars from the N. Pole down to 31° South Declination are included. At the same time a person wishing to make investigations is supplied with complete references which will enable him to collect all the observations relating to each particular pair. Obviously their inclusion would have necessitated another volume. When various catalogues of discoveries are thus brought together and the pairs arranged in order of R.A. in one general catalogue the discovery numbers do not run in any particular order, and it becomes difficult to find a pair. Professor Burnham has, in vol. i., a compact table, very ingeniously arranged, which enables easy reference to be made to any pair, either in vol. i. or vol. ii. Thus, on the left hand are numbers from one upwards, and in the succeeding columns, under the heading of the discoverer, the reference number in the "General Catalogue." Suppose we wish to look up β 151—opposite 151, under Burnham,

is the reference. This table is not described in the introduction, and may well be overlooked. It also gives at once the number of pairs discovered by any observer. The catalogue has been published by the Carnegie Institute and freely distributed, and Professor Burnham is to be congratulated on the completion of so great and important a work. Reviews of the work are in various journals; and an appeal is made for measures of the wider pairs from the Astrographic plates.

T. L.

Variable Stars.

The rate of discovery of new variable stars is well maintained in 1907, the last number allotted officially in the *A.N.* being 180, which represents the number of announcements during the year.

As usual, Harvard College Observatory shares very largely in this work, the principal notices being as follows:—

<i>H.C.O. Circular.</i>	Number of New Variables.	Remarks.
127	14	Discovered in pursuance of a scheme referred to below. All except one above 10^m at max. Maps 3 and 6.
129	15	In maps 31 and 62. All 10^m or above at max. except one.
130	71	In maps 9, 12, 21, 48, and 51. All above 10.5^m at max.
131	...	Details of a group of red stars near <i>Nova Velorum</i> .
132	15	From an examination of stars with peculiar spectra. All above 10^m .
133	15	In maps 15, 18, and 27.

Independently of the above, *Harvard College Observatory Annals*, vol. lx. part 4, refers to 1777 variables discovered in the two Magellanic Clouds, some of which have been previously announced. Part 5 gives particulars of 10 new Algol type variables, all south of decl. -15° . -

H.C.O. Circular 127 describes a practical method of search for variables of moderate brightness by superposing a negative upon a contact print of a second negative, covering the same region of the sky, but taken at a different date from the first. These photographs are large; that is, each covers a portion of the sky about 30° square, there being 55 maps for the whole sky. Already a considerable number of new variables have been brought to light, as indicated above; and a continuation of the scheme will probably result in approximately sweeping up all the known variables of a "moderate" degree of brightness.

Much work has recently been done at H.C.O. in continued photographic observations of known variable stars.

This observatory has issued a *Second Catalogue of Variable Stars* containing 1957 stars, including those in globular clusters. If we add the 1791 variables found in the Magellanic clouds, we get a total of 3748 known variables, of which considerably more than half have been found at Harvard. The full and accurate details of each star, together with a series of interesting remarks, critical and historical, render this undoubtedly the leading work of reference on the subject.

Vol. lvii. part 1, *Annals H.C.O.*, contains the observations of 75 classical variables of long period, made by the "method of Argelander," during the years 1902-1905 inclusive. The results of the observations are also given in the shape of dates of maxima and minima, as well as full details of the light curves, etc.

During the past year has been published series iv. of the *Atlas Stellarum Variabilium* by the Rev. Father J. G. Hagen, S.J. This fine work represents the practical completion of the atlas, which must be *the* handbook for all observers of variables. It is on the same general lines as the preceding series, and contains 100 variables of various types, whose minima can be followed in telescopes of moderate size. For each star there is a beautifully printed chart, quarto size, giving the telescopic vicinity of the variable, the lines of R.A. and Dec. being in red, and a separate list of comparison stars, the magnitudes of which have been determined with great care. It would take up too much space here to do full justice to this meritorious work, the publication of which marks an epoch in the history of variable star research. It may be added that series v. of the Atlas, which has not been referred to in these notes, and which contains 49 stars whose minimum is below 7^m , was published in 1906.

In addition to the foregoing, when account is taken of the work done in this country and on the Continent in 1907, it is plain that the department of Stellar Variation continues to occupy an important position in astronomical work.

E. E. M.

Stellar Distribution.

A very noteworthy addition to our knowledge of the parallaxes of stars is contained in the *Yale Observatory Transactions*, vol. ii. pt. 1, published towards the end of 1906. An extensive list of parallaxes, all determined on a uniform plan and with approximately the same degree of trustworthiness, is provided. The list consists of 163 stars, the observations being made by Dr. Chase, Mr. Smith, and Dr. Elkin, using a heliometer. Some idea of the magnitude of the undertaking may be gathered from the fact that it had been in progress for thirteen years. With a very few exceptions the stars selected were those having proper motions exceeding $40''$ per century, and not hitherto observed for parallax. It is noteworthy that not a single parallax exceeding $0''.20$ was found; the mean parallax was about $0''.05$. In general

the results appear to confirm Professor Kapteyn's tables of the mean parallax corresponding to given magnitude and proper motion. The deduced values of the linear velocities of the stars are on the average considerably higher than the mean velocities of stars deduced from line-of-sight determinations with the spectroscope; but it is pointed out that this is only to be expected, seeing that the stars were specially selected on account of their large apparent motions.

At the meeting of the British Association at Leicester, Sir David Gill devoted a large part of his presidential address to the subject of stellar distribution and the structure of the universe. Besides giving a general survey of the subject, his address included some unpublished results by Professor Kapteyn as to the distribution of stars in space and their luminosities, revising his earlier estimates, though not changing their general character.

In *Groningen Publications*, No. 18, Professor Kapteyn collects and compares all the available data as to the numbers of stars of various magnitudes in different parts of the sky. The difficulty of reducing the estimates of magnitude made by the different observers to a common standard, so as to render the enumerations of stars strictly comparable, is naturally very great, but seems to have been successfully overcome. The principal result of the paper is an empirical formula exhibiting the number of stars per square degree as a function of the magnitude and galactic latitude. Professor Kapteyn concludes, moreover, that, except in the immediate neighbourhood of the Milky Way, the distribution of the stars does not vary to any great extent with the galactic longitude. This must be taken to indicate that there is little important clustering of the stars except in the Milky Way.

In *Monthly Notices*, 1907 December, the mean distances of the stars of Groombridge's Catalogue are examined from the standpoint of the hypothesis of two star-drifts. Further evidence is given to show that the two drifts must be at sensibly the same mean distance from us, and that accordingly they must permeate one another. It also appears that the mean distance of these stars increases continually as we proceed from the galactic pole to the galactic equator. This is in accordance with the view that the apparently closer aggregation of stars in the galactic plane is not due to a clustering of the nearer stars, but to the fact that additional more distant stars are visible in those directions.

Professor Comstock continues his investigations on the solar motion relative to the very faint stars in *Astronomical Journal*, No. 591. He has now available proper motions of 149 stars, for the most part between the ninth and twelfth magnitudes, derived from double-star measures. From these he derives a position of the solar apex, R.A. 20^h , Dec. $+54^\circ$. The most noteworthy feature is the high declination of the apex. Other investigators have noticed a progressive increase of the declination as fainter stars are used, so that this result, derived from stars fainter than had hitherto been considered, is not unexpected. The same author contributes a paper

on the "Luminosity of the Fixed Stars" to *Astronomical Journal*, No. 597.

Dr. K. Schwarzschild (*Nachrichten der K. Gesell. der Wissen. zu Göttingen*, 1907) has discussed the law of distribution of the motions of the stars. He accepts the recent conclusion that there are two strongly favoured directions of motion, which, when referred to the centre of gravity of the stars, must be directly opposite to one another. On this basis he puts forward a frequency law, which, while differing only slightly from that embodied in the two-drift hypothesis, is remarkably well adapted for mathematical treatment and calculation, and, moreover, regards the universe as a single instead of a dual system. According to Dr. Schwarzschild's law, the frequency of a velocity (u, v, w) is proportional to $e^{-A(u^2-B(v^2+w^2))}$, where $A < B$. This stands in much the same kind of relation to the Maxwellian law, $e^{-A(u^2+v^2+w^2)}$, that a prolate spheroid does to a sphere; this distribution may in fact be derived from the random distribution by increasing all the component velocities parallel to the axis of x in a certain ratio. This axis corresponds to the direction of relative motion of the two drifts on the other theory. A careful analysis of the Greenwich-Groombridge proper motions on the new theory shows a very satisfactory accordance between theory and observation. No suggestion is made in the paper as to a theoretical basis for the law proposed; presumably some such distribution might arise if the universe (or that part of it which is here concerned) had originally been in the form of a very elongated ellipsoid.

• A. S. E.

Astrographic Chart and Catalogue.

Additions to the published *Astrographic Catalogue* have been made during the year by the following observatories:—Catania, Zone 51° N., 0^h to 3^h R.A.; Potsdam, volume iv., Zone 32° N.; Oxford University, volume ii., containing the whole of Zone 30° , and volume iii., Zone 29° ; Paris, volume ii., Zone 23° N.; and Bordeaux, volume ii., Zone 16° N.,—the word "Zone" implying in all cases the plates whose centres are at the declinations named, and the stars included therefore lie between declinations approximately 1° less and greater. The second volume of the *Greenwich Astrographic Catalogue*, which completes the northern cap 65° to the pole, allotted to the Royal Observatory, is on the eve of publication, so that substantial progress is being made.

The above-named observatories have all published previous volumes except Catania, whose contribution, though entitled vol. v. part 1, is the first issued from that observatory. The scheme of this work follows that of the Helsingfors Catalogue, each plate being taken as a unit, and all the stars it contains measured. In the columns of the catalogue these measures are given, and with these, in parallel columns, their values when corrected by application of the plate constants. These corrected measures are con-

verted into Right Ascension and Declination, and are given for each star on every plate to thousandths of a second of R.A. and hundredths of a second in Declination. This is a very complete programme, since it makes the results at once available for comparison with other catalogues, but entails much work, and publication is therefore not rapid. Since the original resolution of the organising committee provided only for the publication of rectilinear co-ordinates, most of the co-operating observatories prefer to first publish simply the measures, and to leave the equatorial co-ordinates for later volumes.

It appears from the reports of the Colonial observatories that the measurement of the plates of Zones 41° S. to the South Pole is proceeding. The plates of Zones 24° to 40° S., divided between Cordoba (S. America) and Perth (W. Australia), are being taken, and there is prospect that these will be measured soon. The work both on the Chart and Catalogue is progressing actively at Tacubaya (10° S. to 16° S.).

Enlargements of the chart plates have been distributed during the year by the Directors of the Paris, Algiers, Toulouse, Bordeaux, San Fernando, Tacubaya, and Greenwich Observatories. The total number issued from these observatories is now—

Paris	296	San Fernando	145
Algiers	281	Tacubaya	23
Toulouse	147	Greenwich	736
Bordeaux	65		

It is understood that the Potsdam Observatory does not propose to take the chart plates 32° to 39° N., but that these zones will be undertaken by the Royal Observatory of Belgium.

It would be unfitting to close this note without making reference to the loss that the work has suffered by the death of M. Loewy, Director of the National Observatory, Paris, who was so much associated with the International Chart of the Heavens. Four French observatories are taking part in this undertaking, and within the last few years three of them—Algiers, Bordeaux, and Paris—have lost their Director by death. M. Baillaud, who succeeds M. Loewy at Paris, is the only survivor of the four French astronomers who superintended the work when it was begun.

H. P. H.

Stellar Spectroscopy in 1907.

New Star.—In last year's report, reference was made to the discovery of a star exhibiting the photometric peculiarities of a Nova. Professor E. C. Pickering announced it (*H.C.O. Circular* 121) as *Nova Velorum*. The spectrum had not then been observed, but in *H.C.O. Circular* 131 (*Ast. Nach.*, 176, 255) Professor Pickering announces that Mrs. Fleming has recently found that its

spectrum exhibits bright lines which appear to coincide with bright lines in the later spectrum of *Nova Persei* No. 2 1901. Many other interesting spectra of red stars have been found in its neighbourhood.

Professor Hartmann has succeeded in photographing the spectrum of *Nova Persei* No. 2 (1901) with a specially constructed spectrograph. The star was fainter than the eleventh magnitude. The spectrum was obtained with $8\frac{1}{4}$ hours' exposure, and was found to resemble the spectrum of the *Wolf Rayet* star (*Ast. Nach.*, 177, p. 113).

Studies of Special Stars.—*o Ceti*.—The bright maximum of this star in December 1906 and January 1907 was well observed by spectroscopists. Father Sidgreaves (*M.N.*, lxvii. 534) ascribes the unusual intensity of the maximum to weakness of the absorption bands, which usually form the main feature of the spectrum. He also records peculiar behaviour of the hydrogen lines. Father Cortie (*Astroph. Jour.*, xxvi. 123) discusses the bearing of recent observations of *o Ceti* on the question of the temperature of sun-spots. Mr. Slipher contributes two notes (*Astroph. Jour.*, xxv. 66 and 235) on the spectrum of this star. He points out that the hydrogen line $H\alpha$ (C), as well as $H\beta$, $H\gamma$, and $H\delta$, appears bright on his photographs, and that the absorption lines of *Vanadium* are very strong, a fact which is well brought out by a beautiful plate illustrating the spectrum from $\lambda 4100$ to $\lambda 7000$ with comparison spectra of *Va*, *Fe*, and *Na*. Mr. Plaskett (*Jour. R.A.S., Canada*, i. 45, with plate) gives an account of his studies of the spectrum; his measurements of the velocity in the line of sight are in good agreement with those made by Professor Campbell in 1898.

α Orionis.—Mr. Newall and Mr. Cookson (*M.N.*, lxvii. 482) have discovered three absorption flutings in the extreme red end of the spectrum of this star. They also give results of a comparison of sun-spot lines with marked lines in the green region of the spectrum of the star.

β Orionis.—Sir N. Lockyer (*Proc. R.S.*, 80, 50) has detected lines attributable to sulphur in the spectrum of *β Orionis*.

ϵ Capricorni.—Mr. Slipher (*Astroph. Jour.*, xxv. 285) finds bright lines in the spectrum, and regards the star as likely to prove to be a binary.

α Scorpii.—Mr. Lunt (*M.N.*, lxvii. 487) gives reason for suspecting the presence of tin in the atmosphere of *α Scorpii*.

α Boötis.—Mr. Lunt (*Proc. R.S.*, 79, 118) has found several lines attributable to *Europium* in the spectrum of *α Boötis*, and discusses the evidence afforded by the spectrum of the solar chromosphere for the presence of this element in the Sun.

These careful researches of Mr. Lunt, originating in the detection of small abnormalities in velocity deduced for special stellar lines, afford a good instance of the way in which our knowledge of terrestrial spectra may be helped by studies of stellar spectra.

Two lists of stars, having peculiar spectra, have been issued by Professor Pickering. The first (*H.C.O. Circular* 124, and *Ast.*

Nach., 174, 101) relates to 33 stars, of which 18 have been found to be variable stars; the second (*H.C.O. Circular* 132, and *Ast. Nach.*, 176, 258) relates to 23 stars, of which 15 are found to be variable stars. The long-continued success of the Harvard College observers in connecting peculiar spectra with variable stars serves to emphasise the view that typical spectra are evidences of special states of equilibrium in stellar conditions.

Variable Radial Velocity.—Notes on variability of velocity are given for the following stars:—

RZ Cassiopeiæ	Yerkes Observatory	<i>Astroph. Jour.</i> , xxv. 59
X Cygni	"	" "
13 Ceti	"	" "
ω Leonis	"	" "
85 Pegasi	"	" "
19 τ_5 Eridani	"	" "
33 τ_8 Eridani	"	" "
20 τ Orionis	"	" "
4 ξ_1 Canis Majoris	"	" "
ϵ Cygni	Küstner	<i>Ast. Nach.</i> , 175, 87
ζ Cygni	"	" "
σ Leonis	Zurhellen	" 173, 353
α Draconis	Harper (Ottawa)	<i>Jour. R.A.S.</i> , Canada, i. 237.
U Cephei	Slipher	<i>Astroph. Jour.</i> , xxv. 284
X Carinæ	Wright	<i>L.O.B.</i> , No. 123
ι Gruis	"	" "
σ Tauri	Campbell and Moore	" "
f Tauri	" "	" "
7 Camelopardalis	" "	" "
A Boötis	" "	" "
β Coronæ	" "	" "
ξ Cygni	" "	" "
d Tauri	" "	" "
ζ Cephei	" "	" "

Orbits of Spectroscopic Binaries.—Orbits have been calculated for the following spectroscopic binaries:—

α Andromedæ	Ludendorff	<i>Ast. Nach.</i> , 176, 327	<i>e</i> 0·4
κ Cancri	Ichinohe	<i>Astroph. Jour.</i> , xxv. 315	0·15
β Arietis	Ludendorff	" xxv. 320	0·88
μ Sagittarii	Ichinohe	" xxvi. 157	0·44
α Carinæ	H. D. Curtis	<i>L.O.B.</i> , No. 122	0·18
α Pavonis	"	" "	0·01
κ Velorum	"	" "	0·19
θ Draconis	"	" "	0·01
ω Draconis	A. B. Turner	" No. 123	0·01
η Virginis	Ichinohe	<i>Astroph. Jour.</i> , xxvi. 282	0·25
Mean eccentricity			0·25

Dr. See (*M.N.*, lxviii., current volume, 201) states that the average eccentricity among visual binaries is considerably more than twice that among spectroscopic binaries, the average value for 30 of the latter systems being 0.22.

Dr. Zuhellen (*Ast. Nach.*, 175, 246) contributes remarks on the analytical determination of orbits of spectroscopic binaries.

Dr. Knut Laves (*Astroph. Jour.*, xxvi. 164) describes a simple graphical method based on the use of the hodograph.

Standards of Wave-length.—Messrs. Benoit, Fabry, and Perot (*C.R.*, 144, 1082) have redetermined the number of wave-lengths of the red cadmium ray in a metre. The resulting wave-length of the cadmium ray, viz. 6438.4702, has been adopted by the International Union for Solar Research as the single primary standard for spectroscopic measurements. This value agrees with the previous determination by Michelson and Benoit within one ten-millionth part.

Messrs. Fabry and Buisson (*C.R.*, 143, 165, and 144, 782) have published wave-lengths of 115 standard lines in the spectrum of the iron arc, between the wave-lengths λ 2373 and λ 6495. This work is a contribution to the plan of co-operation in the determination of wave-lengths of lines, which will be adopted as secondary standards, lines at intervals of 50 Ångström units throughout the spectrum: the wave-lengths being determined by the interferometer method, as far as possible with an accuracy of 0.001 unit.

Herr Eversheim (*Astroph. Jour.*, xxvi. 172) describes his investigations in determinations of secondary standards. He points out that his wave-lengths seem to be all slightly larger than those of Fabry and Buisson, and states that he is looking for the origin of this systematic difference.

The system of tertiary standards at intervals of from 5 to 10 units will be chosen and determined when the secondary system is complete. The wave-lengths of the tertiary standards will be obtained by interpolation between the secondary standards with the help of large gratings.

Dr. Kayser (*Astroph. Jour.*, xxvi. 190) regards the question of the constancy of wave-lengths as decisively settled. Presumably his statements must be taken as referring to suspected displacements much larger than those attributable to small changes in pressure.

New Spectrographic Installations.—In the publications of the Lick Observatory, vol. ix., parts 1-3, Mr. Wright gives an introductory account of the Mills Expedition to the Southern Hemisphere. A 36-inch pierced mirror is mounted at Cerro San Cristóbal, near Santiago. The Cassegrain mounting has been adopted, and a three-prism spectrograph is rigidly fixed at the back of the large mirror. Mr. H. D. Curtis, who, on Mr. Wright's return to the United States in March 1906, was appointed to take charge of the work, gives an account of recent changes (*Pub. A.S.P.*, xix. 227), and describes (*Astroph. Jour.*, xxvi. 256) the method

adopted for minimising the change of focus of the silvered mirror in the course of the night's work. A refrigerator is applied two hours before sunset to reduce the temperature of the mirror by 5° or 6° C. By this plan the changes of focus have been reduced from about 25 mm. to about 5 mm. in the course of the night.

At the Dominion Observatory, Ottawa, Canada, Dr. King has put the spectroscopic work in the charge of Mr. Plaskett. Great activity is shown both in the careful preparation of the instrumental appliances for giving the best results (*Astroph. Jour.*, xxv. 195), and in measurement and reduction of photographed stellar spectra (*Jour. R.A.S.*, Canada, vol. i.). The spectrograph is attached to an equatorial of 15 inches aperture.

Measurement and Reduction of Observations.—Papers dealing with determinations of orbits of spectroscopic binaries are referred to above in the paragraph on binaries.

Mr. Moore (*Pub. A.S. Pac.*, xix. 13) gives a résumé of methods of measurement and reduction of spectrograms.

Mr. Schlesinger (*Pub. Allegheny Obs.*, vol. i.) describes a method which he has found useful for simplifying the reduction of measurements.

Colours of Telescopic Binary Stars.—Sir William and Lady Huggins (*Astroph. Jour.*, xxv. 65) call attention to the corroboration which their view, expressed in 1897, receives from Mr. Lewis's discussion of the relative masses of the components of 18 binary stars: "the apparent satellite is in fact the primary of the system" (*Mem. R.A.S.*, 56, xx). Sir W. Huggins had suggested in 1897 that the bluish component of a pair might have the greater mass, and for this reason be still at the earlier evolutionary stage.

Theoretical Investigations.—Professor Schwarzschild (*Nach. K. Gesellsch. Gottingen*, 1906, Heft 1) has suggested a third alternative to isothermal and adiabatic equilibrium in radiating stellar atmospheres. He calls it radiative equilibrium. The problem to be solved is as follows: If in the Sun's atmosphere the various strata are regarded as simultaneously radiating and absorbing, and if convective motions were to cease, what distribution of temperature would have to be reached in the various strata in order that the observed steady flow of energy should be transmitted without further change of temperature? He finds a solution, proves that the equilibrium is stable, and proceeds to show that radiative equilibrium under certain simplified assumptions gives a good account of the observed darkening of the Sun's limb, whereas adiabatic equilibrium fails.

H. F. N.

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Bologna, Royal Academy of Sciences.
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Bordeaux, Society of Physical and Natural Sciences.
Boston, American Academy of Arts and Sciences.
Brazil, Sociedade Scientifica de São Paulo.
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Brussels, Royal Academy of Sciences of Belgium.
Buda-Pesth, Hungarian Academy of Sciences.
Buda-Pesth, Royal Hungarian Institute for Meteorology
and Terrestrial Magnetism.
Calcutta, Asiatic Society of Bengal.
Canada, Geological Survey.
Canada, Royal Society.
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Dijon, Academy of Sciences.
Egypt, Survey Department.
Geneva Observatory.

Geneva, Society of Physics and Natural History.
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Göttingen, Royal Society of Sciences.
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Helsingfors, Finnish Society of Sciences.
India, Survey Department.
International Bureau of Weights and Measures.
Italian Geodetic Commission.
Kasan, Imperial University.
Kasan, University Observatory.
Kodaikánal Observatory.
Von Kuffner Observatory.
La Plata Observatory.
Leiden Observatory.
Leipzig, Astronomical Society.
Leipzig, Prince Jablonowski Society.
Leipzig, Royal Society of Sciences of Saxony.
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Paris, École Polytechnique.
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Paris, Philomathic Society.
Pennsylvania, Lehigh University.
Perth Observatory, Western Australia.
Philadelphia, American Philosophical Society.
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Potsdam, Central International Geodetic Bureau.
Potsdam, Royal Prussian Geodetic Institute.
Prague, Imperial Observatory.
Pulkowa Observatory.
Pulkowa, Physical Observatory.
Queensland Geographical Journal.
Rio de Janeiro Observatory.
Rome, Italian Society of Sciences.
Rome, Royal Academy *dei Lincei*.
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San Francisco, Astronomical Society of the Pacific.
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Stockholm, Royal Swedish Academy of Sciences.
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Toulouse Observatory.
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Turin, Royal Observatory.
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United States Coast and Geodetic Survey.
Upsala Observatory.
Upsala, Royal Society of Sciences.
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Vienna, Imperial Academy of Sciences.
Vienna, Imperial Geodetic Bureau.
Vienna, Imperial Military Geographic Institute.
Wanganui Astronomical Society.

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ADDRESS

Delivered by the President, Mr. H. F. Newall, on presenting the Gold Medal of the Society to Sir David Gill, K.C.B., F.R.S.

FOR the second time in the history of our Society, your President is called upon to present the Gold Medal to Sir David Gill. By their award in 1882 the Council desired to recognise the value of his work in determining the solar parallax from observations of Mars in Ascension; and now, after a quarter of a century, they have awarded the Gold Medal to him in recognition of his contributions to the Astronomy of the Southern Hemisphere, and his other astronomical work.

In fulfilling the task which it is my privilege to attempt this afternoon, I would begin by assuring Sir David Gill of the pleasure which it is to us to have him at home again among us with his vigour unabated. We look forward to the prospect of our having him help in our counsels for many years to come.

The terms of the Council's award are wide. They cover the large range of work which Sir David Gill has accomplished during the twenty-eight years of strenuous activity which he has spent in his capacity as His Majesty's Astronomer at the Observatory of the Cape of Good Hope. It would be a difficult matter to decide whether Sir David Gill has contributed to the advance of astronomy in those years more by his own observational work or by the active performance of his administrative duties. Fortunately it is not part of my task to try to disentangle these two aspects of his work.

Broadly speaking, by his personal labours we have such achievements as his two sets of heliometer determinations of the parallaxes of certain southern stars, and his three determinations of the solar parallax. By his administrative activity the Cape Observatory has been equipped entirely anew with modern first-class instruments; a vast store of astronomical material has been rendered available for the use of astronomers; not only are the last remaining observations of his predecessors reduced and published, but also the observational materials collected in Sir David Gill's régime are reduced and published up to date.

And, as if these duties were not enough to occupy him, Sir David Gill devoted himself to promoting a unified scheme of geodetic survey of South Africa. In his latest utterance about this work in his Presidential Address to the British Association, Sir David Gill speaks of the great African arc on the 30th meridian.

He says of it that it is the dream of his life to see it completed. When I heard these words at Leicester, it seemed to me that they represented Gill's general frame of mind. Whenever he set his hand to any bit of work, it became the dream of his life to see that particular bit of work completed in the most comprehensive way that he could attain. This frame of mind does not always meet with sympathy; it is liable at times to rouse keen opposition. But Gill has seldom failed to infect others with something of his own enthusiasm.

In doing honour to Gill's work, we shall not in the least detract from it if we pay the sincerest tribute to the co-operation which he has been able to elicit from many workers in many lands. We must not forget the devotion of his staff at the Cape Observatory. We must remember the liberal support he has received from the Lords Commissioners of the Admiralty, both for increased instrumental equipment and for increased staff to deal with the expanded scope of the work. We must pay a tribute to the memory of our late Fellow, Frank McClean, whose generous munificence provided the astrophysical department at the observatory. We shall not forget the services rendered by Professor Kapteyn in the *Cape Photographic Durchmusterung*, nor those of Dr. Elkin and Dr. Auwers in their allotted tasks in the solar parallax work, nor yet those of Sir W. Morris and many other officers in the geodetic work.

Paying tributes in this wise is only a way of recognising Gill's power of inspiring others to take part in advancing the subject which it is the object of our Society to encourage.

History and Traditions at the Cape.—It has been of great interest, in preparing to write this address and in trying to attune myself to the nature of the surroundings in which Sir David Gill has worked, to trace back through the prefaces of early volumes of observations and through the annual reports something of the history and traditions of the Royal Observatory at the Cape of Good Hope. What an enthralling history it would make for us astronomers if it were written by someone who had the power of picturesque presentation.

We should see Fallows, the first astronomer at the Cape (1821–1831), awaiting for three and a half years the delayed plans of his observatory, and filling up his spare moments by opening a school and teaching the children of neighbouring farmers—his fee for each lesson a load of earth, which helped to make the foundation of a garden on the rocky hill chosen for the site of the observatory. We should hear of his applying in vain for permission to measure an arc of meridian.

We should read how he struggled on, making the best of his portable instruments, till the observatory buildings were finished and the permanent instruments were installed—seven years after his arrival at the Cape. Then, after a couple of years of vigorous observations, his able assistant Captain Ronald fell sick, and Fallows would have been left alone at the work but for the

assistance which his wife learned to render by taking the circle readings whilst he was engaged with the transit. It was generous official help that he needed, but before it arrived fever had attacked him and he died in the forty-third year of his age. It is a sad story of a brave man struggling to implant new work in a distant land, and it should make us remember the debt of help that we at home owe to those who are working at a distance from headquarters.

Next we should read of Henderson, who went to the Cape in 1832 and worked there assiduously for thirteen months before he uttered that wail of despair about the situation of the observatory on Snake Hill. He describes it as "on the verge of an extensive sandy desert, exposed to the utmost violence of the gales which frequently blow, without the least protection from trees or other objects to shelter from the wind or sun, some miles from markets, shops, or the habitation of persons with whom those belonging to the observatory can associate." It was in such surroundings that Henderson, with the assistance of Lieut. Meadows, achieved those observations which have made his name famous. He took most of his material back to Edinburgh, and year by year he found time, in the midst of his duties as Astronomer Royal for Scotland, to reduce it all. Our Society had the honour of publishing in its early memoirs fifteen contributions from him dealing with his Cape observations, including his memorable determination of the parallax of α Centauri.

Next we should find Maclear (1834-1870) boldly coming out, at heart a true colonist, making roads, harnessing the wind to draw a water-supply, carting earth, planting trees and rows of pine and wattle to form shelter. By exchange and sale and purchase of land he consolidated the observatory property, and succeeded in getting convenient communication with the main road to Cape Town. Of his scientific labours, it is enough to recall his measurement of an arc of meridian, his multitudinous meridian observations, partly reduced under his own régime, and revised and published by his successors Stone and Gill in the form of four Cape Catalogues for the equinoxes 1840, 1850, 1860, and 1865, which deal with a total of 10,766 stars. In his régime, too, two equatorials were added to the equipment, and with these his observations of comets, nebulae, double stars, and occultations were made. A new transit-circle was installed.

So, at the end of Sir Thomas Maclear's directorate in 1870, when he withdrew from the observatory to live for the remaining nine years of his life at Mowbray, within a mile of the scene of his former labours, we should see Stone (1870-79) coming out to the Cape to find an established home and an observatory containing a transit-circle the facsimile of that at Greenwich. Stone was at once engrossed in completing two great objects, (i) the preparation of Maclear's meridian observations for press, and (ii) the re-observation of the stars which had been observed by Lacaille more than a century before. He completed the latter undertaking by the formation of the Cape Catalogue for 1880, containing the places of 12,441 southern stars to the seventh magnitude. During his directorate

he passed through the press two Cape Catalogues for 1840 and 1860, based on Maclear's observations made during thirteen years.

This is in briefest outline the history of the observatory at the Cape of Good Hope up to the year 1879, when Stone returned to England to take up his duties as Radcliffe Observer at Oxford. We have seen the traditions forming—

(1) The stellar parallax tradition, implanted by Henderson in his studies of α Centauri, and fostered by Maclear.

(2) The geodesy tradition, implanted first in African soil by the Abbé Lacaille, in vain desired by Fallows, and firmly rooted by Maclear.

(3) The tradition of the Cape Catalogue, implanted by Fallows in his first catalogue of 273 stars, fostered by Airy in his reduction of Fallows' last observations, and firmly fixed by Maclear and Stone,—in fact, the traditions of general astronomy.

Into all this goodly heritage of history and tradition Sir David Gill entered in 1879; and looking back upon the records of his directorate, we find he has fostered and extended each one of the traditions he found at the Cape, and has implanted as many more as he found.

Thus by the accumulated labours of its Directors the Cape Observatory has grown to be an observatory of the first rank, of which the nation may justly be proud.

Stellar parallax.—First and foremost among the new traditions we must put the heliometer tradition. Gill's masterly use of this instrument has given us those refined determinations of stellar parallax and of solar parallax, those observations of planets and satellites, and triangulations of stars, that are so honourably connected with his name.

Let me first refer to the determinations of stellar parallaxes, one of his most notable contributions to the astronomy of the southern hemisphere. He has made two sets of determinations; the first were made with a 4-inch heliometer. This instrument was an old friend, for he had used it in Lord Crawford's expedition to Mauritius in 1874, and had also made his observations of Mars with it at Ascension in 1877. Gill knew he could use it effectively in stellar parallax determinations, and he had acquired it from Lord Crawford for this purpose. Just before he left Europe to take up his duties at the Cape, Gill was fortunate enough to find a young and able astronomer eager to join him in the parallax work. He invited him to come to the Cape as soon as he should have finished his studies at Strassburg. Thus it was that Dr. Elkin went out to the Cape in 1881. For more than two years, a guest in Gill's house, he took his share in Gill's labours, and made it a labour of love.

Their programme of parallax observations was an interesting one. First on the list of chosen stars was, of course, α Centauri, Henderson's star, which still retains its place as the nearest star in the whole sky. Altogether nine of the most interesting stars in the southern heavens were included on the observing list, four

stars, including α Centauri, being chosen for historical associations or for conspicuous brightness, and five others for large proper motion. These stars were judiciously divided between the two observers, so that each had six stars on his list. The comparison stars were chosen with great care, and in the case of the three stars common to the two lists each observer had his special comparison stars, so that we must regard the determinations as entirely independent. Each observer discussed his own observations, and the results were combined in the final account of the research published in the *Memoirs* of our Society, vol. xlviii. (1884).

The results were valuable, both in their bearing on the exact solution of the problem undertaken and by the effects produced by their attainment, for immediately after the completion of the work Sir David Gill represented to the Admiralty that continued research on stellar parallax and a new determination of the solar parallax by observations of minor planets were much to be desired, if only they could be carried out with a larger instrument provided with certain structural improvements which experience with the small heliometer had suggested. The Lords Commissioners promptly sanctioned the addition of a 7-inch heliometer to the equipment of the Cape Observatory.

Regular observing was begun with the new heliometer in January 1888, and in the next four years an astonishing programme of observations was successfully completed. It included—

(1) The complete determination of the constants and errors of the heliometer (scale value, errors of the micrometer screw and of the scale divisions, etc., involving nine months' labour).

(2) Observations for parallax of twenty-two stars.

(3) Observations of the three minor planets, Iris, Victoria, and Sappho, for the determination of solar parallax.

(4) Observations of Jupiter's satellites.

Gill's expectations of the new heliometer were fully realised; he satisfied himself that one observation made with it was of the same weight as three observations with the old instrument, and that one set of observations could be made in half the time that had been previously required.

The tables which summarise (in vol. vii. of the *Annals of the Cape Observatory*) the results for stellar parallax contain details relating to 12 *bright* stars and 10 stars of *large proper motion*; and among the 32 distinct determinations the name of our Medallist is attached to 18, Elkin's to 7, Finlay's to 3, and de Sitter's to 4. In several instances, by way of test, the parallax of the same star was investigated with both instruments, with substantially the same results. Gill completes his exposition of the observations by a discussion of the conclusions to be drawn from the results obtained. So far as so small a number of parallaxes as 22 can be utilised for such a generalisation, the Cape results seem to support the view which has gradually formed in the last twenty years, namely, that large proper motion is a safer criterion of proximity of a star to our system than brightness. We have learnt from the work of

Stumpe, Kapteyn, and Newcomb and others to realise how much emphasis is to be laid on the probability that stars differ enormously in actual luminosity.

The point is beautifully illustrated by the tables which Gill has drawn up. It must be remembered, as he points out, that the derived parallaxes are differential or apparent, not absolute; for we are not at liberty to assume that the comparison stars are infinitely remote. The only legitimate procedure is to deal with limiting values, which can be obtained by adopting different hypotheses as to the absolute parallax of the comparison stars. Gill accordingly gives tables exhibiting the variation of the total light radiated by each of his parallax stars (in terms of the Sun's light), with different hypothetical parallaxes of the comparison stars, ranging from $0''.00$ to $0''.05$. It is thus made clear that the southern stars whose apparent parallaxes have been determined would differ in brightness by about 12–15 magnitudes if they were all removed to the same distance from the Sun.

The further tables which Gill gives to convert the observed proper motions of his parallax stars into absolute velocities in miles per second afford strong confirmation that the deductions about actual luminosity are legitimate. For the velocities deduced are nearly all within the limits which spectroscopic determinations have led us to expect among stars.

The beautiful photographic reproductions, given in the volume of results, of the spectra of α_2 Centauri and the Sun show what may be expected of the astrophysical department which Sir David Gill has laboured to develop at the Cape. I will not attempt to refer in detail to this spectroscopic work; for though the papers published by the Cape Observatory hitherto have dealt with important points, we are able to gather from references in the annual reports that the main forces are concentrated on yet another determination of the solar parallax by the spectroscopic method. We can well imagine the interest with which Sir David Gill is looking forward to the results of the work.

Cape Catalogues.—Before passing on to refer to Gill's work on solar parallax, I would advert to another of his large contributions to the astronomy of the southern hemisphere, namely, his faithful fostering of the Cape Catalogue tradition. Meridian work must necessarily form an important part of the work of a large national observatory. At the Cape much of the energy of the staff has always been devoted to this branch, and the result is a series of catalogues of star places which have a special value.

When Gill took up his duties at the Cape he found that, in spite of the indefatigable zeal of Mr. Stone, there were two periods (1849–52 and 1861–70) of valuable observations of Sir Thomas Maclear which still remained to be reduced and published. Stone had already begun the reduction of the observations of the first period, and Gill made it one of his first duties to complete and revise the reduction, and in 1884 the Cape Catalogue of 4810 stars for 1850 was published. The last remaining period (1861–70) of

Maclear's observations was dealt with by degrees, and in 1900 the Cape Catalogue of 1905 stars for 1865.0 was published. We can well understand with what satisfaction the completion of this work was hailed. The preface contains the following remark:—"The publication of this catalogue marks an epoch in the history of the observatory. For the first time in that history the Director can feel that the accumulated labours of his predecessors are available for the use of astronomers, and that the work being done under his own direction is in a healthy and forward state of reduction and publication."

The first catalogue for which Sir David Gill is solely responsible is a catalogue of 1713 stars for 1885.0 published in 1894; the next is a catalogue of 3007 stars for 1890.0 published in 1898. In 1906 two more catalogues were published, an achievement of which the meridian circle department might well be proud. One is a catalogue of 8560 astrographic standard stars for the equinox 1900, to serve for the Cape section of the Astrographic Catalogue. The other is a catalogue of 4464 stars for the equinox 1900, based on observations made between 1900 and 1904, and containing, *inter alia*, the results of Cape observations of 2798 zodiacal stars which were entered on the list circulated by Sir David Gill, and adopted at the Paris Conference in 1896 as a list of stars suitable for reduction of heliometer observations of planets, etc. In this connection I may refer to another large undertaking. Since 1897 all the oppositions of major planets have been observed with the heliometer at the Cape.

The transit-circle, which has been in use since 1856, was carefully renovated in 1885. The instrument is similar to that at Greenwich. I wish I could have included in these remarks reference to a fifth catalogue, which will deal with other observations, already on the way to completion at the time of Sir David Gill's leaving the Cape. We shall look forward to it with great interest, for it will contain the results of comparison of the old and the new transit-circles at the Cape.

Gill has laboured to embody in the new transit-circle, which was erected in 1901, many new features which were designed with the object of making it possible to detect or eliminate all ascertainable sources of error in observations of fundamental stars.

In connection with his efforts to probe into these refinements of observational work, I would recall to your memory his careful discussion of the meridian observations made for the reduction of his heliometer measures of Mars at Ascension. He then definitely discovered that curious variation of personal equation known as the magnitude equation. In virtue of this troublesome peculiarity, a transit observer watching the passage of bright and faint stars over a wire records the transit a little later for a faint star than for a bright star. The result is that the right ascension interval between a faint and a bright star is a little too large when the bright star leads, and is a little too small when the faint star leads. The effect is a small one, but is very troublesome in cases where

great refinement is needed in star places; the trouble is all the greater because the magnitude of the effect varies appreciably among different observers.

Sir David Gill has introduced in the Cape Catalogues, *e.g.* that of Astrographic Standard Stars for 1900'0, corrections for magnitude equation applied separately for each observer. The latest contribution to the experimental study of the effect is one made at the Cape Observatory, and communicated to our Society last April. The authors, Sir David Gill and Mr. Hough, discuss therein the results of a comparison of right ascension differences measured in three independent ways—(1) with the old transit method, (2) with the new transit and travelling wire, and (3) with the heliometer. The results show that within the range of magnitudes ($3\frac{1}{2}$ – $8\frac{1}{2}$) of the stars observed, the magnitude equation is barely appreciable with the new transit-circle fitted with the travelling wire.

Cape Photographic Durchmusterung.—I turn now to remind you of another great undertaking which we owe to the initiative of our Medallist, viz. the *Cape Photographic Durchmusterung*. There is scarcely need for me to refer to it in any detail, for the history of it must be vivid in your memory from the account which Dr. Glaisher gave of it in presenting the Medal to Professor Kapteyn in 1902. The *Cape Photographic Durchmusterung* arose out of the success which Gill achieved in photographing the comet of 1882; he saw the beauty of the many star-images that appeared on the photograph down to the 9th magnitude, and soon afterwards he proved that large photographic cameras could be effectively employed for constructing photographic star maps. He proceeded forthwith to secure the systematic photographic survey of the southern skies, and gave us what may be briefly described as an extension of the *Bonn Durchmusterung* to the South Pole. Kapteyn's measurement and reduction of the plates remains a splendid instance of scientific devotion. It gives us, under the title of the *Cape Photographic Durchmusterung*, in three large volumes of the *Annals of the Cape Observatory*, the approximate places and magnitudes of 454,875 stars,—in fact, a catalogue of all the stars down to the $9\frac{1}{2}$ magnitude, and most of those to the 10th magnitude between declination 19° S. and the South Pole. This survey has not only served admirably for a study of stellar distribution in the sky, but by the industrious co-operation of Professor Kapteyn at Groningen and Mr. Innes at the Cape it has also led to the discovery and study of many variable stars, a fact which is attested by observations recorded in the fourth volume, containing the details of the work of revision of the *C.P.D.*

Astrographic Chart and Catalogue.—The present year is the twenty-first anniversary of the inception of the *Astrographic Chart and Catalogue*. In the original initiation of this scheme of international co-operation Sir David Gill took a deep interest and also a large share. Admiral Mouchez, by whose tact and energy the initial steps of promoting the harmonious co-operation of

eighteen observatories in different parts of the world were successfully conducted, has testified to the fact that Gill's success in photographing the comet of 1882 opened the way to the Chart, for it proved that we had reached the point of being able to construct the chart of the heavens by photography. The skill of the Brothers Henry, not only in developing the construction of object-glasses large enough and suitably achromatised for stellar photography, but also in producing their superb photographic star charts, was probably the decisive factor in the acceptance of the plan agreed upon in 1887.

The Cape Observatory at once became one of the eighteen contributories to the scheme; the zone -40° to -52° was allotted as its portion of the sky. The astrographic telescope made by Sir H. Grubb arrived at the Cape in 1890, and after some alterations and experimental researches the work was begun in 1893 and has gone steadily forward. By the end of 1897 the required 1512 catalogue plates had all been obtained and nearly half of the chart plates. In the following year it was decided to re-photograph the whole zone for the catalogue, in order to bring the epoch at which the plates were taken nearer to that at which the comparison stars were observed on the meridian. This plan also rendered it possible to determine with sufficient accuracy the proper motions of the reference stars in the numerous instances where no meridian observations existed previous to the epoch of the latest Cape observations.

In 1900 Sir David Gill undertook, in addition to the zone, to photograph the area within 2° of the South Pole, originally allotted to the Melbourne Observatory; it will thereby be possible to combine the photographic work with the Cape heliometer triangulation of this region, and with the results of the Cape discussions of all the meridian observations of southern close circumpolar stars.

The measurement of the plates was well started in 1898, with the aid of a new type of measuring apparatus designed by Gill (*M.N.*, lix. 61); a second measuring instrument of the same type was afterwards added; and at the time of Sir David Gill's retirement from the directorate in February 1907 he was able to announce that 1086 out of the 1512 catalogue plates had been measured. It is thus seen that the zone undertaken by the Cape Observatory is well on the road to completion.

Solar Parallax.—In these days, since the discovery of minor planets with peculiar orbits like that of Eros, it is not easy to speak of the older methods of determining the solar parallax in such a way as not to appear antiquated. Yet, in a retrospect over the gradual development of the methods, there are points of great interest.

It is just half a century since Airy summarised his views of the relative values of available methods of determining the solar parallax from observations of Venus and Mars. His summary was given by way of calling attention to approaching favourable oppositions of Mars in 1860, 1862, and 1877, and the two transits of

Venus in 1874 and 1882. He pressed on the attention of astronomers the importance of observing Mars; in fact, he summed up strongly in favour of the Mars method, but at the same time he urged that the future astronomical public would not be satisfied unless all practical use were made of the transits of Venus.

It is easy to criticise after events, but looking back, with our present knowledge as to where success lies, we cannot fail to be struck with the statesmanship which Airy showed in looking far ahead and calmly reviewing beforehand the broad chances of success in attempts to utilise special opportunities for the settlement of astronomical problems.

Airy's summary reads as if he had been truly a seer of what was to be, but also as if he hardly had the courage to let so uncommon an occurrence as a transit of Venus pass by without making observations. His view was that Mars, approaching within 0.4 unit of the Earth in favourable opposition, would give better values of the Sun's parallax than Venus.

Galle of Breslau proposed in 1872 that instead of Mars one of the minor planets would be more suitable, on the ground that the smaller disc of such a planet would more than make up for the greater distance from the Earth. Galle favoured observations in both hemispheres; Airy seems rather to have thought of observations to be made at a single observatory.

It was Gill's fortune to have learned at Dunecht Observatory to appreciate the worth of the heliometer as an instrument of precision; he saw that to apply the heliometer to observations for solar parallax was the great opening. Through many of the years in the '70's he worked at this problem. At Mauritius, whither he went in 1874 with Lord Lindsay to observe the transit of Venus, he made his heliometer measures of the minor planet Juno. At Ascension, in 1877, he used the heliometer to observe Mars, and his discussion of the observations gave results of high importance. Still Gill was unsatisfied: the size, colour, and phase of Mars made observations and discussion not perfectly satisfactory. The dream of his life would not be accomplished till he could determine the solar parallax afresh from observations of minor planets with a large heliometer.

He contributed a broad discussion of the other available methods in a series of papers communicated to *The Observatory* in 1877. He summed up in the sense that the minor planet method promised a completely satisfactory solution of the problem. This conviction was only deepened by the results of the heliometer observations of stellar parallax to which I have already referred.

Looking forward to available opportunities, Gill found that Iris in 1888 and Victoria and Sappho in 1889 would be exceptionally favourably placed; and being assured of the co-operation of Elkin at Yale, the work was undertaken. I have already alluded to the prompt response of the Admiralty to Gill's request for a 7-inch heliometer for the execution of the project.

The employment of the diurnal method at the Cape was not

completely satisfactory, nor was the transport of the observer and instrument to some equatorial station compatible with Gill's other duties. The only course open was to combine the southern heliometer observations with corresponding observations in the northern hemisphere. Hence the co-operation of the directors of the observatories that possessed heliometers—viz. Yale, Leipzig, Göttingen, Bamberg, and Oxford (Radcliffe)—was invited and promptly given.

Methods were devised to meet the case of the employment of heliometers in different hemispheres. To this end the comparison stars were as far as possible selected so that when the planet was situated at the greatest zenith distance at which good observations can be made (that is, when the parallax factor is the greatest attainable), the two comparison stars should be situated one above and one below the planet. In this way the determination of the parallax is made to rest upon differences of two nearly equal distances measured by means of the heliometer.

Special attention was directed to the important point of arranging matters so that the observations themselves furnish the material for the determination and elimination of the errors. The method was to be, so far as practicable, "self-correcting." Errors of scale were eliminated by selecting stars nearly equidistant from the planet; errors due to personal habit of the observer were minimised by the use of a reversing prism inserted between the eyepiece and the observer's eye, so as to bring the apparent direction of separation of the images always into the same position with reference to the vertical. The same comparison stars were used in both hemispheres, and thus errors in the adopted positions of the stars were eliminated. The cunning choice of the comparison stars along the course of the three planets is well shown in the charts given in the volumes vi. and vii. of the *Annals of the Cape Observatory*, which contain the full account of the observations.

For the meridian observations of the stars the co-operation of many different observatories was asked for, and Sir David Gill summed up the situation as follows:—

"The wide-felt scientific need of such an undertaking may be assumed to be demonstrated by the fact that almost every astronomer who was appealed to entered with heart and soul into his allotted share of the work, and probably no similar astronomical undertaking has ever before received such universal and powerful co-operation."

Twenty-two observatories co-operated. Altogether 9620 observations of 115 stars were utilised; they were discussed and combined by Dr. Auwers, who also visited the Cape and took part in the observations of Victoria. From this able and thorough discussion of the meridian observations, coupled with the heliometer triangulations, the places of the comparison stars were derived with unusual accuracy. Dr. Auwers also reduced the 760 meridian observations of the planets and derived a value of the solar parallax, viz. $8''.806 \pm 0''.03$, a value which agrees well with

that derived from the heliometer observations, though it is of much smaller weight.

The resulting heliometer determinations of the solar parallax were—

From Victoria, . . .	8"8013 ± 0"0061
„ Sappho, . . .	8"7981 ± 0"0114
„ Iris, . . .	8"8120 ± 0"0090
Mean, . . .	8"8036 ± 0"0046

—three independent determinations which agree within the limits of their probable errors.

Geodesy.—At a meeting of the British Association in South Africa (Report B.A., 1905) Sir David Gill gave an account of yet another enormous piece of work which has been carried out under the influence of his far-seeing initiative. He records how he felt that one of the duties laid on him by the traditions of the observatory and the labours of his predecessors was to interest himself in the geodetic survey of the colony.

Lacaille had measured an arc of $1\frac{1}{4}^{\circ}$ northwards from Cape Town in 1752. The result showed that this southern arc indicated a figure of the Earth unsymmetrical about the equator.

Nearly a century later (1841–48) Maclear revised and extended Lacaille's arc to $4\frac{1}{2}^{\circ}$. His result showed that the arc measured was, within narrow limits, consistent with a figure of the Earth that exhibited no difference in the northern and southern hemispheres. Lacaille's contrary deduction was found to be mainly attributable to a large local disturbance of the direction of gravity at one of the terminal stations.

Soon after his appointment as Astronomer at the Cape, Sir David Gill laid before Sir Bartle Frere, then Governor of Cape Colony, a proposal to create a system of geodetic triangles as a basis for the future accurate survey of the colony. It was a fortunate concurrence for the colonies and for geodesy that these two men—the one with his experience of Indian administration and his knowledge of the requirements of the colony, and the other with his scientific weight and practical enthusiasm—were able to deal with this question. After many administrative difficulties had been overcome, the actual work was begun in 1883. Thus was inaugurated a survey which must be an enduring benefit to the colonies, for already troubles and litigation were beginning to arise from incompatible surveys over small areas. The survey is founded upon a complete principal triangulation laid down with scientific accuracy. This could hardly have been achieved but for the initiation of Sir David Gill and the splendid devotion of Colonel Morris, R.E. (now Sir William Morris), who was in charge of the field work, ably supported by Lieut. Laffan, R.E., and other officers.

Step by step the geodetic survey has been extended, always under the scientific direction of Sir David Gill. As astronomers we may perhaps be allowed for the moment to lose sight of the

practical advantages accruing to the colonies, and to concentrate attention on the geodetic aspect of this great work.

The surveys of Cape Colony and Natal were completed in 1896, including a rediscussion of Maclear's triangulation (*Geodetic Survey of South Africa*, vol. i.), and a new reduction of Bailey's survey 1859-62 (vol. ii.). Rhodesia was then begun in 1897, and the triangulation was carried from near Bulawayo (lat. 22° S.) to within 75 miles of the southern end of Tanganyika ($8^{\circ}40'$ S.).

Next, in 1902, the principal triangulation of the Transvaal and the Orange River Colony was undertaken, under the superintendence of Sir W. Morris, Gill being responsible for the initiation of the work, and acting as scientific adviser. The field work was nearly completed in 1905, and the trained parties were just about to be disbanded. Sir David Gill realised that if this occurred there would be a gap left between the Limpopo River and Bulawayo in South Rhodesia, with little likelihood of its being completed. But his energetic persistence succeeded in securing support by the intervention of Sir George Darwin, whereby the relatively small link of 120 miles in the chain was made good. Thus the triangulation is complete from the southern extremity of Africa nearly to the southern end of the German Protectorate, an arc of 25° in latitude.

It is to be hoped that the German Government will be able to continue the measurement of the arc along the eastern shore of Lake Tanganyika on German territory; all the more so because, by yet another instance of Sir David Gill's energy, the measurement of an arc of $2\frac{1}{2}^{\circ}$ to the north of the German territory is now being carried out.

The delimitation of the Anglo-German boundary between British Bechuanaland and German South-West Africa along the 20th meridian gave rise to some temporary difficulties in 1896. Sir David Gill was in England at the time, and was consulted by the Colonial Office. His knowledge of local conditions was invaluable; he received instructions to proceed to Berlin, and there he was able to arrange an agreement satisfactory to both of the Governments concerned, and the direction of the work was placed in Sir David Gill's hands. Bosman's longitude arc across Bechuanaland to the 20th meridian was connected at both east and west ends with the geodetic circuit in Cape Colony.

This great system of triangulation pervading South Africa will eventually give geodetic results relating to three considerable arcs of meridian:—

First, the arc along the meridian of 19° E. longitude, with an amplitude of $12\frac{1}{2}^{\circ}$.

Second, the arc along the meridian of 26° E. longitude, with an amplitude of $8\frac{1}{2}^{\circ}$.

Third, the great arc along the 30th meridian, with an amplitude of 25° .

As far as the reductions are completed, it would appear that there is but slight deviation from Clarke's elements of the figure of

the Earth on any of these meridians. But in the second and third there seems to be evidence that the astronomical amplitude exceeds the geodetic by a small fraction of a second of arc per degree.

From the north, preliminary operations have already been begun by Captain Lyons of the Egyptian Survey to connect Cairo with the southern triangulation.

Sir David Gill's dream will be realised when, by the junction of Cairo round the east shores of the Mediterranean with Greece, and so with Struve's arc, the North Cape in lat. 70° N. is connected by triangulation with the southernmost point of Africa, lat. 35° S., an arc of meridian 105° in length.

My task has been a difficult one. Wisely or unwisely, I have attempted to set before you the broad lines along which Sir David Gill's achievements lie. In doing so, I have had, perforce, to leave many points of interest and importance untouched, even at the risk of seeming to fail in doing justice to his work.

I hope I have been able, however inadequately, to make clear to you that the recognition of the Council has fallen upon work of extraordinary scope, not only in administrative activity, but also in investigations of high refinement and permanent value.

Sir David Gill,—In presenting this medal to you, let me say that we know that for yourself the successful achievement of your tasks is the highest reward. But we could not deny ourselves the satisfaction of recording our appreciation of the mark which your labours in a distant land have made in the advance of astronomy. Let me convey to you the hope that your well-earned leisure may be filled with continued study of the science which you love.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

President.

H. F. NEWALL, Esq., M.A., F.R.S.

Vice-Presidents.

Sir DAVID GILL, K.C.B., LL.D., D.Sc., F.R.S.

Major P. A. MACMAHON, D.Sc., F.R.S.

W. H. MAW, Esq.

H. H. TURNER, Esq., D.Sc., F.R.S., Savilian Professor of Astronomy, Oxford.

Treasurer.

Major E. H. HILLS, C.M.G.

Secretaries.

THOMAS LEWIS, Esq.

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Sir W. H. M. CHRISTIE, K.C.B., M.A., D.Sc., F.R.S.,
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ALFRED FOWLER, Esq., Assistant Professor of Physics, South Kensington.

J. W. L. GLAISHER, Esq., M.A., Sc.D., F.R.S.

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